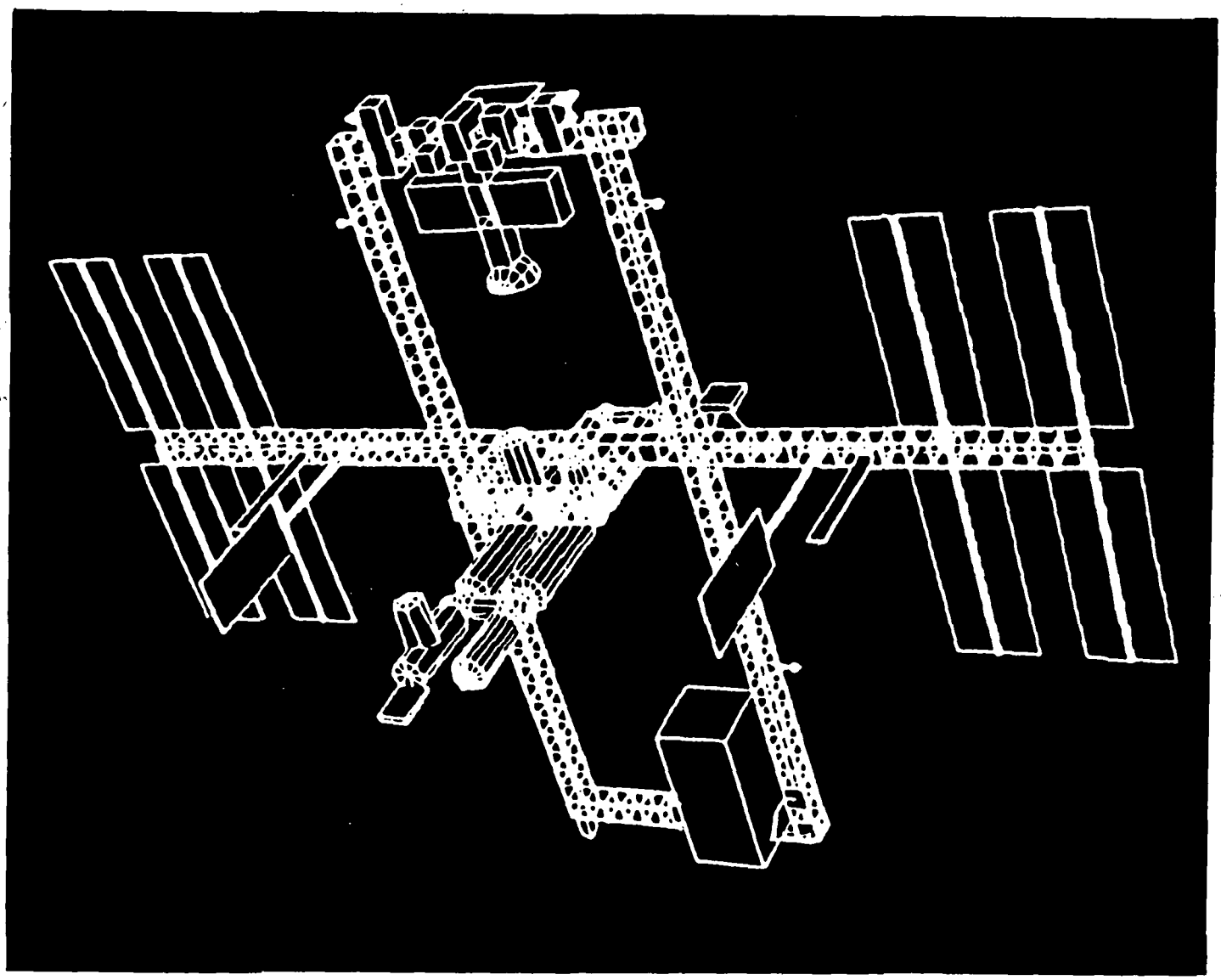
Space Station Systems

A Bibliography
with Indexes

NASA SP-7056(02)
July 1986



NASA SP-7056(02)

SPACE STATION SYSTEMS

A BIBLIOGRAPHY WITH INDEXES

Supplement 2

Compiled by
Technical Library Branch
and
Edited by
Space Systems Division
NASA Langley Research Center
Hampton, Virginia

A selection of annotated references to unclassified reports and journal articles that were introduced into the NASA scientific and technical information system between July 1 and December 31, 1985 in

- *Scientific and Technical Aerospace Reports (STAR)*
- *International Aerospace Abstracts (IAA).*

Scientific and Technical Information Branch 1986
National Aeronautics and Space Administration
Washington, DC

NOTE TO AUTHORS OF PROSPECTIVE ENTRIES:

The compilation of this bibliography results from a complete search of the *STAR* and *IAA* files. Many times a report or article is not identified because either the title, abstract, or key words did not contain appropriate words for the search. A number of words are used, but to best insure that your work is included in the bibliography, use the words *Space Station Systems* somewhere in your title or abstract, or include them as a key word.

This supplement is available from the National Technical Information Service (NTIS), Springfield, Virginia 22161 at the price code A10.

INTRODUCTION

This bibliography is designed to be helpful to the researchers, designers, and managers engaged in the design and development of technology, configurations, and procedures that enhance efficiencies of current and future versions of a Space Station.

This literature survey lists 904 reports, articles and other documents announced between July 1, 1985 and December 31, 1985 in *Scientific and Technical Aerospace Reports (STAR)*, and *International Aerospace Abstracts (IAA)*.

The coverage includes documents that define major systems and subsystems, servicing and support requirements, procedures and operations, and missions for the current and future Space Station. In addition, analytical and experimental techniques and mathematical models required to investigate the different systems/subsystems and conduct trade studies of different configurations, designs, and scenarios are included. A general category completes the list of subjects addressed by this document.

The selected items are grouped into categories as listed in the Table of Contents with notes regarding the scope of each category. These categories were especially selected for this publication and differ from those normally found in *STAR* and *IAA*.

Each entry consists of a standard bibliographic citation accompanied by an abstract, where available, and appears with the original accession numbers from the respective announcement journals.

Under each of the categories, the entries are presented in one of two groups that appear in the following order:

(1) *IAA* entries identified by accession number series A85-10,000 in ascending accession number order;

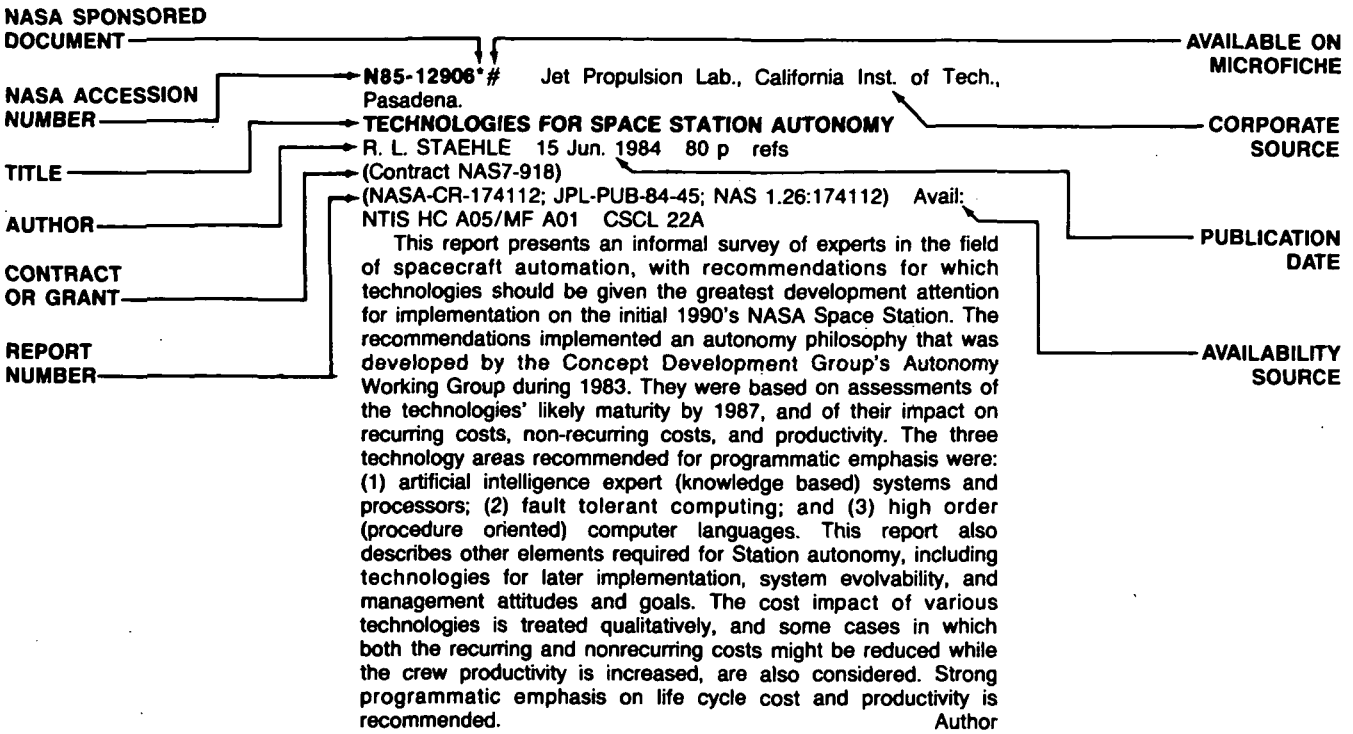
(2) *STAR* entries identified by accession number series N85-10,000 in ascending accession number order.

After the abstract section there are seven indexes—subject, personal author, corporate source, foreign technology, contract number, report number, and accession number.

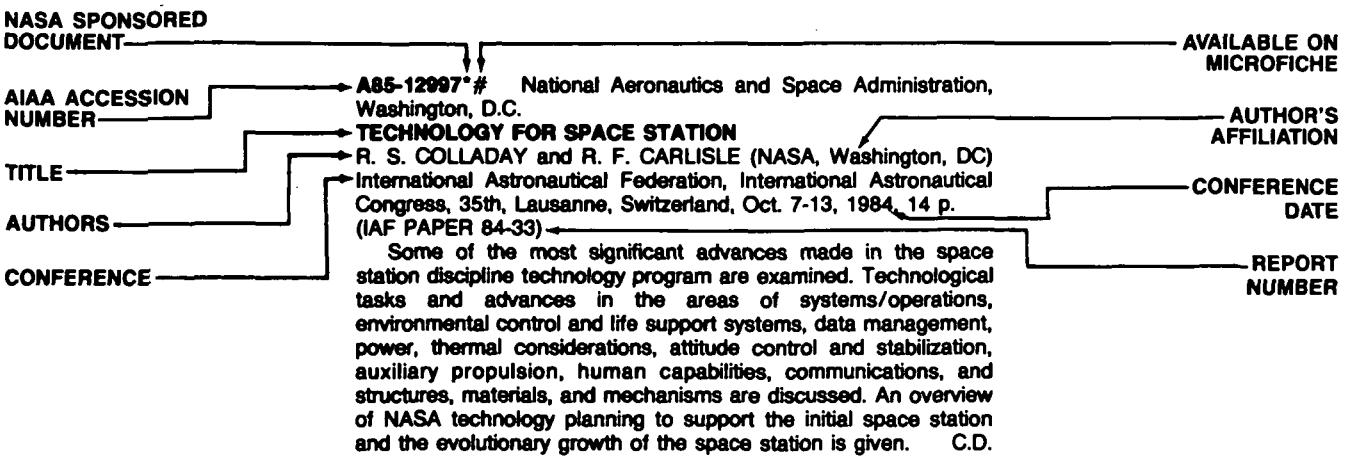
A companion continuing bibliography, *"Technology for Large Space Structures,"* is available as NASA SP-7046.

TABLE OF CONTENTS

TYPICAL CITATION AND ABSTRACT FROM *STAR*



TYPICAL CITATION AND ABSTRACT FROM *IAA*



SPACE STATION SYSTEMS

A Bibliography (Suppl. 2)

JULY 1986

01

SYSTEMS

Includes system requirements for proposed missions, mission models, overall conceptual configuration and arrangement studies; systems analyses for future required technology; and identification and description of technology developments and experiments for the elements of a complete Space Station system.

A85-30304#
INTEGRATED DESIGN AND ANALYSIS APPROACH FOR LARGE PRECISION STRUCTURES
H. J. BAIER and G. HELWIG (Dornier System GmbH, Friedrichshafen, West Germany) IN: Structures, Structural Dynamics, and Materials Conference, 26th, Orlando, FL, April 15-17, 1985, Technical Papers. Part 1 . New York, American Institute of Aeronautics and Astronautics, 1985, p. 713-719. refs
(AIAA PAPER 85-0805)

This paper discusses the design, analysis and optimization approach for large precision structures such as telescopes and antennas. The task is presented as a multidisciplinary problem requiring the consideration of material, deployment mechanisms, stiffness, launch and in orbit response etc., more or less simultaneously. These problems and their interrelation are addressed with special emphasis on methods for in orbit performance optimization also including active elements. It is shown that by appropriate decomposition and interfacing of the different subtasks a reasonable approach for system analysis and optimization can be obtained. Author

A85-47040*# McDonnell-Douglas Astronautics Co., St. Louis, Mo.
ASSEMBLING THE BASIC STRUCTURE
C. COVINGTON (NASA, Johnson Space Center, Houston, TX), R. F. THOMPSON (McDonnell Douglas Astronautics Co., St. Louis, MO), and S. Z. RUBENSTEIN (Rockwell International Corp., Space Station Systems Div., Downey, CA) *Aerospace America* (ISSN 0740-722X), vol. 23, Sept. 1985, p. 50-52.

Specific tasks to be undertaken by the NASA-Johnson, Phase B management of the manned Space Station are described. These tasks include the analysis, definition, and design of the following systems: assembly trusses and structures; interconnection modules; airlock system; heat rejection and transport; guidance, navigation and control systems; mechanical systems; resource integration; data management; communication and tracking; habitat for the crew; hardware need for cost-effective EVA; interface and berthing for compatible space-transportation system; and software development environment. The components, functions, and the key design goals of each of these systems are discussed. I.S.

02

MODELS, ANALYTICAL DESIGN TECHNIQUES, AND ENVIRONMENTAL DATA

Includes descriptions of computerized interactive systems design and development techniques, computer codes, internal and external environmental models and data.

A85-30227*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
MULTIDISCIPLINARY ANALYSIS AND SYNTHESIS - NEEDS AND OPPORTUNITIES
R. H. TOLSON and J. SOBIESZCZANSKI-SOBIESKI (NASA, Langley Research Center, Hampton, VA) IN: Structures, Structural Dynamics, and Materials Conference, 26th, Orlando, FL, April 15-17, 1985, Technical Papers. Part 1 . New York, American Institute of Aeronautics and Astronautics, 1985, p. 1-12. refs
(AIAA PAPER 85-0584)

A comprehensive evaluation is conducted of structural analysis and synthesis opportunities which emerge through a multidisciplinary design program approach that simultaneously and interactively encompasses, in its determination of a given aircraft design, aerodynamics, structure, structural dynamics, materials, controls, and propulsion. In this way, it becomes possible to rapidly exploit technological advances in order to yield synergistic effects among configurational subsystems. The aircraft type presently considered as recipients of this treatment are commercial transports, high performance military aircraft, rotorcraft, and large space antennas, giving attention to common features among the multidisciplinary design tasks represented. O.C.

A85-30281#
AUTOMATED MESH GENERATION/EDITING SCHEMES FOR TWO- AND THREE-DIMENSIONAL CONTINUUM/DISCRETE FINITE ELEMENT MODELING
B. L. DOWLER, D. K. ROACH, and K. K. TAMMA (West Virginia University, Morgantown, WV) IN: Structures, Structural Dynamics, and Materials Conference, 26th, Orlando, FL, April 15-17, 1985, Technical Papers. Part 1 . New York, American Institute of Aeronautics and Astronautics, 1985, p. 471-479.
(AIAA PAPER 85-0741)

The technology for creating complex geometric models within a computer-aided design framework although rapidly increasing in popularity, is still under developmental stages. Generating and modeling complex structural configurations and data files to serve as input for typical finite element applications are known to be laborious and time consuming. The paper describes basic concepts and features towards the development of useful computer-aided geometric models and generation/editing schemes utilizing computer graphics principles and finite elements. The concepts described in the paper have been successfully applied to generate and model complex structural models with emphasis on applications to aerospace related structures. Author

A85-39857#
STATICS AND GEOMETRY OF UNDERCONSTRAINED AXISYMMETRIC 3-NETS
E. N. KUZNETSOV (Illinois, University, Urbana, IL) American Society of Mechanical Engineers, Winter Annual Meeting, New Orleans, LA, Dec. 9-14, 1984. 4 p. refs
(Contract NSF CEE-82-012099)
(ASME PAPER 84-WA/APM-39)

A 3-net is a system formed by three intersecting arrays of linear flexible members such that every intersection involves one member of each array. The subject of this study is an axisymmetric 3-net where the first array is meridional and the other two are inclined to a meridian at equal but opposite angles. If the net intersections are not fixed the system is underconstrained and, generally, does not possess a unique configuration. However, such systems allow exceptional configurations in which they lack kinematic mobility and admit prestress. Pertinent equations governing the intricately interrelated statics and geometry of axisymmetric 3-nets are developed and some closed-form solutions are obtained. On this basis, two particular classes of immobile (static) 3-nets are synthesized and two corresponding sets of feasible geometric shapes are investigated. Author

A85-47635* Virginia Polytechnic Inst. and State Univ., Blacksburg.
SENSITIVITY CALCULATIONS FOR ITERATIVELY SOLVED PROBLEMS
R. T. HAFTKA (Virginia Polytechnic Institute and State University, Blacksburg) International Journal for Numerical Methods in Engineering (ISSN 0029-5981), vol. 21, Aug. 1985, p. 1535-1546. refs
(Contract NAG1-224)

The calculation of sensitivity derivatives of solutions of iteratively solved systems of algebraic equations is investigated. A modified finite difference procedure is presented which improves the accuracy of the calculated derivatives. The procedure is demonstrated for a simple algebraic example as well as an element-by-element preconditioned conjugate gradient iterative solution technique applied to truss examples. Author

N85-31179*# Brown Univ., Providence, R. I.
APPROXIMATION TECHNIQUES FOR PARAMETER ESTIMATION AND FEEDBACK CONTROL FOR DISTRIBUTED MODELS OF LARGE FLEXIBLE STRUCTURES
H. T. BANKS and I. G. ROSEN (Draper (Charles Stark) Lab., Inc., Cambridge, Mass.) *In* JPL Proc. of the Workshop on Identification and Control of Flexible Space Struct., Vol. 2 p 145-156 1 Apr. 1985 refs Previously announced as N84-29903
(Contract NAS1-17070; NAS1-17130; NAG1-258; NSF MCS-82-0355; AF-AFOSR-0198-81)
Avail: NTIS HC A19/MF A01 CSCL 22B

Approximation ideas that can be used in parameter estimation and feedback control for Euler-Bernoulli models of elastic systems are discussed. Focusing on parameter estimation problems, the authors outline how one can obtain convergence results for cubic spline-based schemes for hybrid models involving an elastic cantilevered beam with tip mass and base acceleration. Sample numerical findings are also presented. R.J.F.

N85-31180*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
SPACE STATION PARAMETRIC MODELS
M. HAMIDI and S. J. WANG *In its* Proc. of the Workshop on Identification and Control of Flexible Space Struct., Vol. 2 p 157-199 1 Apr. 1985 refs
Avail: NTIS HC A19/MF A01 CSCL 22B

The development of two parametric models for a four-panel planar initial space station is described. The derivations of the distributed parameter model are presented in detail with the hope that the same method and procedures can be employed for stations with different configurations or for changes within the same configuration class. The 19-DOF finite-element model is also described. With the availability of the 19-DOF and a lower-DOF space station models, the frequency characteristics of the various dynamical systems in the space station environment are identified. R.J.F.

N85-34511*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
HARDWARE MATH FOR THE 6502 MICROPROCESSOR
R. KISSEL and J. CURRIE Jul. 1985 18 p refs
(NASA-TM-86517; NAS 1.15:86517) Avail: NTIS HC A02/MF A01 CSCL 09B

A floating-point arithmetic unit is described which is being used in the Ground Facility of Large Space Structures Control Verification (GF/LSSCV). The experiment uses two complete inertial measurement units and a set of three gimbal torquers in a closed loop to control the structural vibrations in a flexible test article (beam). A 6502 (8-bit) microprocessor controls four AMD 9511A floating-point arithmetic units to do all the computation in 20 milliseconds. Author

03

STRUCTURAL CONCEPTS

Includes analyses and descriptions of different Space Station structural concepts, arrangements, testing, methods of construction and/or manufacturing and specific rotary joints, structural nodes, and columns.

A85-30242#
POST BUCKLING BEHAVIOR OF INDETERMINATE TRUSSES - EXPERIMENTAL INVESTIGATION
R. PURASINGHE (North Dakota State University, Fargo, ND), W. MUELLER, H. ERZURUMLU (Portland State University, Portland, OR), and A. WAGNER (Bonneville Power Administration, Portland, OR) IN: Structures, Structural Dynamics, and Materials Conference, 26th, Orlando, FL, April 15-17, 1985, Technical Papers. Part 1 . New York, American Institute of Aeronautics and Astronautics, 1985, p. 152-159.
(AIAA PAPER 85-0638)

The paper presents an experimental investigation of load redistribution characteristics of indeterminate trusses after the compression members reach their ultimate loads. A description of test set up, instrumentation and test procedure is included. A comparison of test results with an analytical computer code based on limit analysis of indeterminate trusses is presented. The results suggested that significant savings can be realized by applying a Limit State Analysis for indeterminate trusses such as transmission towers. Author

A85-30261#
PRELOAD MODELING, ANALYSIS AND OPTIMUM DESIGN TECHNIQUES FOR BEAM/ROD/CABLE ELEMENT STRUCTURES
R. C. SHIEH (MRJ, Inc., Fairfax, VA) IN: Structures, Structural Dynamics, and Materials Conference, 26th, Orlando, FL, April 15-17, 1985, Technical Papers. Part 1 . New York, American Institute of Aeronautics and Astronautics, 1985, p. 299-307.
(AIAA PAPER 85-0692)

This paper presents an optimization method for achieving a predefined structural shape in a space frame. It also presents a general analysis method for structural enforced deformations that are required to preload a structure exactly to a set of prescribed values via turn-buckles or in a structural analysis using MSC/NASTRAN. The analysis and optimization of a cable tensioned stabilized hoop/column the antenna reflector structure is presented to demonstrate the application of these methods. The optimization method minimizes the sum of the squares of the displacement of the strain energy in the preloaded structure with respect to a predefined shape. The independent optimization variables used are the enforced deformations. Author

A85-30264#
DEPLOYMENT ANALYSIS OF THE OLYMPUS ASTROMAST AND COMPARISON WITH TEST MEASUREMENTS
M. EIDEN, O. BRUNNER, and C. STAVRINIDIS (ESA Structures and Configuration Section, Noordwijk, Netherlands) IN: Structures, Structural Dynamics, and Materials Conference, 26th, Orlando, FL, April 15-17, 1985, Technical Papers. Part 1 . New York, American Institute of Aeronautics and Astronautics, 1985, p. 325-332.
(AIAA PAPER 85-0695)

An analytical procedure is presented to predict the deformations and member loads of a coilable deployable continuous-longeron space mast (Astromast) in the transfer zone from stowed to deployed configuration. A nonlinear 3-D finite element model is set up to represent each single truss member and the initial prestressing of the straight deployed mast. By applying the appropriate loading procedure the mast is forced into its characteristic helical transfer shape where the truss elements are highly loaded and which allows coiling up of the longerons for stowage. The change from deployed mast state into the coiling up configuration is computed with the large strain/displacement nonlinear finite element program LARSTRAN. The analytical results are verified by test measurements on a demonstration mast model and show good agreement. Author

A85-30265*# California Univ., Los Angeles.
ALTERNATIVE APPROXIMATION CONCEPTS FOR SPACE FRAME SYNTHESIS
R. V. LUST and L. A. SCHMIT (California, University, Los Angeles, CA) IN: Structures, Structural Dynamics, and Materials Conference, 26th, Orlando, FL, April 15-17, 1985, Technical Papers. Part 1 . New York, American Institute of Aeronautics and Astronautics, 1985, p. 333-348. refs
(Contract NSG-1490)
(AIAA PAPER 85-0696)

A method for space frame synthesis based on the application of a full gamut of approximation concepts is presented. It is found that with the thoughtful selection of design space, objective function approximation, constraint approximation and mathematical programming problem formulation options it is possible to obtain near minimum mass designs for a significant class of space frame structural systems while requiring fewer than 10 structural analyses. Example problems are presented which demonstrate the effectiveness of the method for frame structures subjected to multiple static loading conditions with limits on structural stiffness and strength. Author

A85-30266*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
STRUCTURAL OPTIMIZATION BY GENERALIZED, MULTILEVEL OPTIMIZATION
J. SOBIESZCZANSKI-SOBIESKI (NASA, Langley Research Center, Hampton, VA), B. B. JAMES, and M. F. RILEY (Kentron International, Inc., Aerospace Technologies Div., Hampton, VA) IN: Structures, Structural Dynamics, and Materials Conference, 26th, Orlando, FL, April 15-17, 1985, Technical Papers. Part 1 . New York, American Institute of Aeronautics and Astronautics, 1985, p. 349-364. refs
(AIAA PAPER 85-0697)

In the present development history for both a general multilevel optimization capability and a three-level structural optimization, which is taken to be qualitatively equivalent to a multilevel implementation, a structure is partitioned into a number of substructuring levels where each substructure corresponds to a subsystem. The method is illustrated by a portal framework that decomposes into individual beams, each of which is a box that can be further decomposed into stiffened plates. Substructuring therefore spans three different levels. Since further extensions would only add to the intermediate substructuring levels, the three-level case is qualitatively complete. O.C.

A85-30405*# Duke Univ., Durham, N. C.
PARALLEL SOLUTION OF CLOSELY COUPLED SYSTEMS
S. UTKU (Duke University, Durham, NC) and M. SALAMA (California Institute of Technology, Jet Propulsion Laboratory, Applied Mechanics Technology Section, Pasadena, CA) IN: Structures, Structural Dynamics, and Materials Conference, 26th, Orlando, FL, April 15-17, 1985, Technical Papers. Part 2 . New York, American Institute of Aeronautics and Astronautics, 1985, p. 751-756. NASA-supported research. refs
(AIAA PAPER 85-0782)

An odd-even permutation and a nested dissection technique were used to circumvent the strong seriality of a system of closely coupled equations. The effect of transforming the n x n Hermitian definite positive matrix coefficient on the topology of Cholesky factors is discussed. A series of directed graphs is constructed in order to show the computational steps required for the odd-even permutation. Numerical expressions for the speed-up and efficiency of parallel N-processing techniques and sequential processing by a single computer are derived. Similar expressions are derived for the case of insufficient processing capacity. The application of the odd-even permutation to the ensemble class of computer architectures is demonstrated. I.H.

A85-35093
TORSION/TENSION COUPLING IN RODS [TORSION/ZUG-KOPPLUNG IN STAEBEN]
D. PETERSEN (Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Institut fuer Strukturmechanik, Brunswick, West Germany) (Strukturmechanik-Kolloquium, Brunswick, West Germany, June 7, 1984) Zeitschrift fuer Flugwissenschaften und Weltraumforschung (ISSN 0342-068X), vol. 9, Mar.-Apr. 1985, p. 69-76. In German. refs

Rods, bars, and beams represent the most basic supporting elements of structural mechanics. They are also used in bridges, in helicopter rotor blades, and in wind-energy installations. A very important field of application will be related to the design of large light-weight structures in space. The design procedures involving an employment of the considered structural elements will frequently have to take into account nonlinear relations. The present investigation is concerned with the capability of the currently available procedures to provide the required results, taking into account relations between torsion and tension. A theoretical evaluation is conducted of theories developed by Hodges (1980), Rosen (1980, and Petersen (1982). A comparison of the three methods on the basis of numerical results obtained for certain test cases is also conducted. It is found that the performance of the three considered methods is unsatisfactory. The required procedure must be able to overcome current theoretical inconsistencies and it must be supported by carefully performed experiments. G.R.

A85-35641
STRUCTURAL DESIGN FOR HIGH-POWER PARABOLIC TROUGH CONCENTRATOR ARRAYS IN SPACE
T. G. STERN and E. W. HAYES (General Dynamics Corp., Convair Div., San Diego, CA) IN: Photovoltaic Specialists Conference, 17th, Kissimmee, FL, May 1-4, 1984, Conference Record . New York, Institute of Electrical and Electronics Engineers, 1984, p. 326-329.

The design of a support structure for a space-power photovoltaic concentrator is described. The baseline concentrator uses miniaturized parabolic-trough mirror-radiators to illuminate solar cells at concentration ratios in the range from 10-40 x geometrical. Such a concentrator has unique pointing requirements in that high accuracy (2 degrees) is required in the axis of concentration, while the perpendicular axis allows greater pointing errors (10 degrees or more) with minimal power loss. The array structure was designed with the goal of meeting these pointing requirements under the constraints of given mirror lengths, payload-bay packaging envelopes, and operating disturbances. Structural design parameters included structure weight, array aperture efficiency (packing factor), and packaged volumetric efficiency. The proposed structure uses a rectangular grid of graphite composite beams

backed by a rigidized truss to form a triangular cross-section. This design has projected specific mass as low as 1 kg/sq m for the structural fraction of the array, and can result in concentrator specific powers exceeding 60 W/kg using current technology.
Author

A85-39281
SPACECRAFT SOLAR ARRAY DEPLOYMENT ANALYSIS - A PROBABILISTIC APPROACH
S. S. SIMONIAN (TRW, Inc., TRW Space and Technology Group, Redondo Beach, CA) and W. T. LEE (Aerospace Corp., El Segundo; TRW, Inc., TRW Space and Technology Group, Redondo Beach, CA) IN: Structural dynamics testing and analysis; Proceedings of the Aerospace Congress and Exposition, Long Beach, CA, October 15-18, 1984 . Warrendale, PA, Society of Automotive Engineers, Inc., 1984, p. 81-87.
(SAE PAPER 841583)

The mission objective of the TRW satellite requires four solar arrays be deployed simultaneously following separation from the inertial upper stage (IUS) booster. Due to the mechanical system's tolerances, the mass properties control procedure, and in-orbit temperature variation, as well as the potential for satellite tumbling, the possibility of sequential latch-up of flexible solar arrays becomes realistic. To determine the influence of sequential solar array latching on the deployment loads is, therefore, of great practical importance. Although the problem should be treated as a nonstationary stochatic process, the difficulty in obtaining an exact solution renders the process unsuitable. In response, this paper presents a Monte Carlo method for approximating a solution to such a problem. Author

A85-39320
OPTIMIZATION OF AN ASYMMETRIC TWO-BAR TRUSS AGAINST INSTABILITY
R. H. PLAUT, P. RUANGSILASINGHA, and M. P. KAMAT (Virginia Polytechnic Institute and State University, Blacksburg, VA) Journal of Structural Mechanics (ISSN 0360-1218), vol. 12, no. 4, 1984-85, p. 465-470.
(Contract F33615-83-K-3214)

The response of an asymmetric linear-elastic two-bar truss of predetermined total volume to vertical loading at the internal joint is investigated analytically. The findings of Kamat et al. (1984) and Khot and Kamat (1983) are extended to determine the bar areas which maximize the critical load in the case where either buckling of one or both bars or snap-through instability is allowed. Sample numerical results are presented in graphs and discussed.
T.K.

A85-41099
ASSEMBLY AND MAINTENANCE OF SPACE PLATFORMS
J. SVED (British Aerospace, PLC, Space and Communications Div., Stevenage, England) (British Interplanetary Society, Space Station Symposium, London, England, Apr. 17, 1985) British Interplanetary Society, Journal (Space Stations) (ISSN 0007-084X), vol. 38, July 1985, p. 319-327. refs

Design considerations for space platforms (SP) will, in the Manned Space Station (MSS) era, focus more on the ease of repair and assembly than on optimizing the configuration. The only other constraint will be the capability of being stowed in the Shuttle bay for launch and deployment. Both manned EVA excursions and robot manipulation will be used for on-orbit assembly. The robots may be teleoperated, controlled from the MSS or from the Orbiter. The SP will need to operated nearly independently from the Orbiter power supplies. Maintenance will be governed by the outage time, propulsion and accommodation service costs, manned or robot service, refurbishment requirements, availability of spare parts, and ground support involvement. Various assembly and maintenance scenarios are explored. M.S.K.

A85-41106
A SOLUTION METHOD OF EQUILIBRIUM EQUATIONS FOR LARGE STRUCTURAL SYSTEMS
T. C. CHEU (General Motors Corp., Indianapolis, IN), C. P. JOHNSON, and R. R. CRAIG, JR. (Texas, University, Austin) (George Washington University and NASA, Symposium on Advances and Trends in Structures and Dynamics, Washington, DC, Oct. 22-25, 1984) Computers and Structures (ISSN 0045-7949), vol. 20, no. 1-3, 1985, p. 107-114. refs

In this paper, computational effort and disk storage requirements are optimized for static analysis of large structures using the nested dissection numbering scheme. The locations of nonzero elements of the associated sparse stiffness matrices before and after matrix factorization are predicted and preserved first. A modified active column method is then presented to perform the factorization of the stiffness matrix and perform the forward reduction and backward substitution of the load vectors. The arithmetic operations and backup storage of zero elements are thus avoided. Simply supported plates divided into large number of finite elements are used as examples to illustrate the efficiency of the algorithms developed. Author

A85-41371
STRUCTURE OF SATELLITES, DESIGN PRINCIPLES, TECHNOLOGIES, MATERIALS [STRUCTURE DE SATELLITES PRINCIPES DE CONCEPTION, TECHNOLOGIES, MATERIAUX]
J.-P. GREGOIRE (Aerospatiale, Cannes, France) and C. BRAZZINI (Aerospatiale, Les Mureaux, France) L'Aeronautique et L'Astronautique (ISSN 0001-9275), no. 111, 1985, p. 19-27. In French.

The mechanical engineering asepcts of satellite design comprise arrival of an optimal geometry amenable to construction with minimal effort and assurance of acceptable operation in orbit, including solar panel deployment and stationkeeping. The design is constrained by cost factors, the space environment and the knowledge that, for the present, the satellite must function without human intervention. Trade-offs are made to accommodate launch stresses and the placement of components for operation. Stress analysis of the chosen architectures are carried out by finite element modelling, always working toward minimizing mass, yet retaining sufficient strength to resist the static, vibration, acoustic and thermoelastic loads of launch and orbit. Weight savings are gained with composite components of known mechanical properties. Design features of the Arabsat and TDF1/TVSAT are furnished as examples. M.S.K.

A85-44823
DEFORMATIONS OF AN EXTENDED CRUCIFORM STRUCTURE IN A NEAR-EARTH ORBIT [DEFORMATSII PROTIAZHENNOI KRESTOOBRAZNOI KONSTRUKTSII NA OKOLOZEMNOI ORBITE]
A. I. LOMACHENKO Akademiia Nauk SSSR, Izvestiia, Mekhanika Tverdogo Tela (ISSN 0572-3299), May-June 1985, p. 160-168. In Russian. refs

An analysis is made of the deformation behavior of a cruciform structure consisting of two mutually perpendicular elastic beams with loads fixed to their ends. It is assumed that the center of mass of the structure moves, at a constant angular velocity, along a circular orbit whose radius is much greater than the structure size. A comparison of results obtained for truss and solid beam structures indicates that in both cases deformations are of the same order of magnitude, whereas the weight of the truss structure (and the cost of putting it in orbit) is significantly lower. V.L.

A85-46547
DEVELOPMENTAL RESEARCHES ON THE LIGHTWEIGHT STRUCTURE FOR FUTURE SATELLITE IN THE NATIONAL DEVELOPMENT AGENCY OF JAPAN
T. KAWASHIMA, M. YAMAMOTO, T. YAMAWAKI, and Y. YOSHIMURA (National Space Development Agency of Japan, Tokyo) IN: Recent advances in composites in the United States and Japan; Proceedings of the Symposium, Hampton, VA, June 6-8, 1983 . Philadelphia, PA, ASTM, 1985, p. 410-427.

In recent years, developmental studies have been carried out on lightweight spacecraft structure and several lightweight components in the National Space Development Agency of Japan (NASDA). Presented here are the test results of the structural components which were made of graphite fiber reinforced composites, carbon fiber reinforced composites, and aluminum alloy plate and honeycomb core, etc. First, graphite-epoxy tube trusses were manufactured and tested for use as struts and main frames of the satellite structure. Second, lightweight honeycomb panels were designed and fabricated to provide spacecraft structural components which are used as some equipment panels or stiffened panels. Third, a lightweight solar panel was developed and tested for a 3-axis stabilized spacecraft with sun-oriented solar arrays which are expected to meet the power requirement of more than 1.8 kW. The panel has successfully been tested under acoustic noise environment, thermal cycling, and sinusoidal vibration, and thus qualified for space applicability. Author

N85-22616# European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk (Netherlands).
DEPLOYMENT ANALYSIS OF THE OLYMPUS ASTROMAST AND COMPARISON WITH TEST MEASUREMENTS
M. EIDEN, O. BRUNNER, and C. STARVRINIDIS *In* ESA Photovoltaic Generators in Space p 357-363 Nov. 1984 refs
Avail: NTIS HC A20/MF A01

An analytical procedure to predict the deformations and member loads of a coilable deployable continuous longer on space mast (Astromast) in the transfer zone from stowed to deployed configuration is presented. The change from deployed mast state into the coiled configuration is computed with the large strain/displacement nonlinear finite element program LARSTRAN. Results are verified by test measurements on a demonstration model. Author (ESA)

N85-22620# European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk (Netherlands). Actuators and Mechanisms Section.
DEVELOPMENTS IN DEPLOYABLE MASTS TO SUPPORT FLEXIBLE SOLAR ARRAYS
M. AGUIRRE-MARTINEZ *In* ESA Photovoltaic Generators in Space p 391-398 Nov. 1984
Avail: NTIS HC A20/MF A01

The ERM nut and spindle driven telescopic solar array mast with circular shaped tube sections of thin walled filament wound carbon fiber reinforced epoxy; and the CTM mast based on a biconvex tube that can be flattened and rolled around a drum are presented. The ERM has minimum weight, minimum stowage diameter, the possibility to choose as stowage length the solar array width (or a half of it for double blanket wings), high stiffness and strength, and very high accuracy. The main disadvantage is its long stowage length. The CTM is a closed section giving very good torsional properties, and very high quality mast root stiffness and strength. The load deformation curve of the CTM is linear up to the failure point, there are no stiffness degradations for mederate to high loads. It offers considerable mass savings. Author (ESA)

N85-23827*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
SYNCHRONOUSLY DEPLOYABLE TETRAHEDRAL TRUSS REFLECTOR
H. G. BUSH, C. L. HERSTROM, P. A. STEIN, and R. R. JOHNSON (Lockheed Missiles and Space Co., Sunnyvale, Calif.) *In its* Large Space Antenna Systems Technol., 1984 p 237-250 Apr. 1985 refs
Avail: NTIS HC A20/MF A01 CSCL 22B

For apertures above 50 meters, the high structural stiffness and compact packaging of tetrahedral truss make this concept an attractive candidate for the reflector support structure. Various features of a deployable, foldable, doubly curved tetrahedral truss structure are presented as well as methods used to design the truss geometry and to synchronize deployment of the folding elements. An arc division method for distributing truss nodal locations over a doubly curved reflector surface is shown to decrease differences in surface strut lengths and to increase the geometric similarity of all node condigurations in each strut surface. These features enhance the design of a single node and strut synchronizer mechanism for each surface examined. The folding error resulting from using this approach is minimal. A.R.H.

N85-23832*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
NEW CONCEPTS IN DEPLOYABLE BEAM STRUCTURES
M. D. RHODES *In its* Large Space Antenna Systems Technol., 1984 p 331-348 Apr. 1985 refs
Avail: NTIS HC A20/MF A01 CSCL 22B

The design of deployable structures involves a complicated tradeoff of packaging efficiency, the overall mechanism associated with deploying and latching beam joints, and the requirements and complexity of the beam deployer/repacker. Three longeron deployable beams, controllable geometry beams, and hybrid deployable/erectable beam concepts are evaluated. Author

N85-23835*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
SPACE STATION STRUCTURES
W. SCHNEIDER *In* NASA. Langley Research Center Large Space Antenna Systems Technol., 1984 p 375-392 Apr. 1985
Avail: NTIS HC A20/MF A01 CSCL 22B

A brief overview of some structural results that came from space station skunk works is presented. Detailed drawings of the pressurized modules, and primary truss structures such as deployable single fold beams, erectable beams and deployable double folds are given. Typical truss attachment devices and deployable backup procedures are also given. E.R.

N85-23856*# Boeing Aerospace Co., Seattle, Wash.
THE SPACE STATION AS A CONSTRUCTION BASE FOR LARGE SPACE STRUCTURES
R. M. GATES *In* NASA. Langley Research Center Large Space Antenna Systems Technol., 1984, Pt. 2 p 757-769 Apr. 1985
Avail: NTIS HC A21/MF A01 CSCL 22B

The feasibility of using the Space Station as a construction site for large space structures is examined. An overview is presented of the results of a program entitled Definition of Technology Development Missions (TDM's) for Early Space Stations - Large Space Structures. The definition of LSS technology development missions must be responsive to the needs of future space missions which require large space structures. Long range plans for space were assembled by reviewing Space System Technology Models (SSTM) and other published sources. Those missions which will use large space structures were reviewed to determine the objectives which must be demonstrated by technology development missions. The three TDM's defined during this study are: (1) a construction storage/hangar facility; (2) a passive microwave radiometer; and (3) a precision optical system. B.W.

N85-23862*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
ASSEMBLY CONCEPT FOR CONSTRUCTION OF ERECTIBLE SPACE STRUCTURE (ACCESS) NEUTRAL BUOYANCY TESTING RESULTS
W. L. HEARD, JR. *In its* Large Space Antenna systems Technol., 1984, Pt. 2 p 855-875 Apr. 1985
Avail: NTIS HC A21/MF A01 CSCL 22B

ACCESS, which is an acronym for Assembly Concept for Construction of Erectable Space Structure, is a planned Shuttle flight experiment to assess the potential of a manual on orbit construction concept and generate assembly data for correlation of ground test data. The individual parts (struts and nodal joints used to interconnect the struts) of the beam truss shown attached to the Shuttle in the figure are unpackaged and assembled by two astronauts working from fixed foot restraints (work stations). The planned flight experiment is described and results of the baseline neutral buoyancy simulation of the flight test are presented. Author

N85-25281*# Boeing Aerospace Co., Seattle, Wash.
DEFINITION OF TECHNOLOGY DEVELOPMENT MISSIONS FOR EARLY SPACE STATIONS: LARGE SPACE STRUCTURES Final Report
R. M. GATES and G. REID 30 Nov. 1984 250 p
(Contract NAS8-35043)
(NASA-CR-171446; NAS 1.26:171446; D180-27677-2) Avail: NTIS HC A11/MF A01 CSCL 22A

The objectives studied are the definition of the tested role of an early Space Station for the construction of large space structures. This is accomplished by defining the LSS technology development missions (TDMs) identified in phase 1. Design and operations trade studies are used to identify the best structural concepts and procedures for each TDMs. Details of the TDM designs are then developed along with their operational requirements. Space Station resources required for each mission, both human and physical, are identified. The costs and development schedules for the TDMs provide an indication of the programs needed to develop these missions. Author

N85-25328# Joint Publications Research Service, Arlington, Va.
CONSTRUCTION IN SPACE
A. S. GVAMICHAVA and V. A. KOSHELEV *In its* USSR Rept.: Space (JPRS-USP-85-003) p 49-89 4 Mar. 1985 refs Transl. into ENGLISH from Stroitelstvo v Kosmose (Novoye v Zhizni, Nauke, Tekh.: Ser. Kosmonavtika, Astron.) (USSR), no. 9, Sep. 1984 p 2-58
Avail: NTIS HC A08/MF A01

Future development of cosmonautics assumes use of large size constructions in space, both those of independent significance and those constituting different components of space vehicles. The construction technology used for work in orbit and the peculiarities of construction work in space are discussed. G.L.C.

N85-25374*# National Aeronautics and Space Administration, Washington, D.C.
CONSTRUCTION IN SPACE
A. S. GVAMICHAVA and V. A. KOSHELEV Dec. 1984 62 p refs Transl. into ENGLISH of the book "Stroitelstvo v Kosmose, no. 9/1984" Moscow, Znaniye, 1984 p 1-58 Transl. by Scientific Translation Service, Santa Barbara, Calif.
(Contract NASW-4004)
(NASA-TM-77630; NAS 1.15:77630) Avail: NTIS HC A04/MF A01 CSCL 22B

The development of large space structures to be used in space, as independent elements, and as different components of space vehicles is proposed. The construction technology of building these structures in orbit, and their design features are discussed. E.A.K.

N85-26848*# Astro Research Corp., Carpinteria, Calif.
A STUDY OF STRUCTURAL CONCEPTS FOR ULTRALIGHTWEIGHT SPACECRAFT Final Report
R. K. MILLER, K. KNAPP, and J. M. HEDGEPETH 16 Apr. 1984 90 p refs Sponsored by NASA Prepared for JPL
(NASA-CR-175765; JPL-9950-1064; NAS 1.26:175765; ARC-TN-1127) Avail: NTIS HC A05/MF A01 CSCL 22B

Structural concepts for ultralightweight spacecraft were studied. Concepts for ultralightweight space structures were identified and the validity of heir potential application in advanced spacecraft was assessed. The following topics were investigated: (1) membrane wrinkling under pretensioning; (2) load-carrying capability of pressurized tubes; (3) equilibrium of a precompressed rim; (4) design of an inflated reflector spacecraft; (5) general instability of a rim; and (6) structural analysis of a pressurized isotensoid column. The design approaches for a paraboloidal reflector spacecraft included a spin-stiffened design, both inflated and truss central columns, and to include both deep truss and rim-stiffened geodesic designs. The spinning spacecraft analysis is included, and the two truss designs are covered. The performances of four different approaches to the structural design of a paraboloidal reflector spacecraft are compared. The spinning and inflated configurations result in very low total masses and some concerns about their performance due to unresolved questions about dynamic stability and lifetimes, respectively. E.A.K.

N85-27934*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
DEPLOYABLE CONTROLLABLE GEOMETRY TRUSS BEAM
M. D. RHODES and M. M. MIKULAS, JR. Jun. 1985 18 p refs
(NASA-TM-86366; L-15901; NAS 1.15:86366) Avail: NTIS HC A02/MF A01 CSCL 22B

A study was conducted on a truss beam structural concept that can deploy and maneuver in a serpentine manner to align or position the truss beam tip. The truss beam is composed of a series of rod members connected together at joints that provide the required rotational degrees of freedom. The current study was conducted to evaluate the requirements of the joints and define a mechanical assembly that could provide both high structural stiffness and the required maneuverability. The truss beam requires two joint types; both types were fabricated and incorporated in a demonstration model. An analysis of the concept was performed to define the location and orientation of the beam tip during deployment and serpentine maneuvers. Author

N85-28399# Dayco Corp., Springfield, Mo. Technical Center.
CONTINUUM MODELING OF LATTICED STRUCTURES
S. ABRATE *In* Shock and Vibration Information Center The Shock and Vibration Digest, Vol. 17, No. 1 p 15-21 Jan. 1985 refs
Avail: SVIC, Code 5804, Naval Research Lab., Washington, D.C. 20375 CSCL 20K

Continuum modeling is an efficient method for the analysis of latticed structures. An equivalent continuum model is sought in order to model the overall behavior of a discrete structure. This approach has been applied to several types of structures for many problems, including eigenvalue, transient response, large displacements, buckling, and damping analyses. Author

N85-30336* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
SELF-LOCKING MECHANICAL CENTER JOINT Patent
H. G. BUSH and R. E. WALLSOM, inventors (to NASA) (Kentron International, Hampton, Va.) 21 May 1985 10 p Filed 11 Jun. 1982
(NASA-CASE-LAR-12864-1; US-PATENT-4,518,277; US-PATENT-APPL-SN-387646; US-PATENT-CLASS-403-102; US-PATENT-CLASS-403-322; US-PATENT-CLASS-403-348)
Avail: US Patent and Trademark Office CSCL 13I

A device for connecting, rotating and locking together a pair of structural half columns is described. The device is composed

of an identical pair of cylindrical hub assemblies connected at their inner faces by a spring loaded hinge; each hub assembly having a structural half column attached to its outer end. Each hub assembly has a spring loading locking ring member movably attached adjacent to its inner face and includes a latch member for holding the locking ring in a rotated position subject to the force of its spring. Each hub assembly also has a hammer member for releasing the latch on the opposing hub assembly when the hub assemblies are rotated together. The spring loaded hinge connecting the hub assemblies rotates the hub assemblies and attached structural half columns together bringing the inner faces of the opposing hub assemblies into contact with one another.
Official Gazette of the U.S. Patent and Trademark Office

N85-32026# National Aeronautical Lab., Bangalore (India).
R AND D ACTIVITIES OF THE STRUCTURAL SCIENCES DIVISION
B. R. SOMASHEKAR *In its* R and D Programmes at the Natl. Aeron. Lab. p 77-93 1983 *refs*
Avail: NTIS HC A10/MF A01

The static and dynamic characteristics of flight structures are studied by analytical and experimental techniques in the broad areas of vibration and aeroelasticity, stress analysis and composite structures. Emphasis is placed on development of methods and facilities for large scale and practical applications. In addition, the design, fabrication and testing of various structural components including scaled models employing both metallic and non-metallic materials are undertaken. Static, dynamic, thermal and aeroelastic characteristics are studied. R.J.F.

N85-33181*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
DEPLOYABLE-ERECTABLE TRADE STUDY FOR SPACE STATION TRUSS STRUCTURES
M. M. MIKULAS, JR., A. S. WRIGHT, JR., H. G. BUSH, J. J. WATSON, E. B. DEAN, L. T. TWIGG, M. D. RHODES, P. A. COOPER, J. T. DORSEY, and M. S. LAKE Jul. 1985 200 p refs
(NASA-TM-87573; NAS 1.15:87573) Avail: NTIS HC A09/MF A01 CSCL 22B

The results of a trade study on truss structures for constructing the space station are presented. Although this study was conducted for the reference gravity gradient space station, the results are generally applicable to other configurations. The four truss approaches for constructing the space station considered in this paper were the 9 foot single fold deployable, the 15 foot erectable, the 10 foot double fold tetrahedral, and the 15 foot PACTRUSS. The primary rational for considering a 9 foot single-fold deployable truss (9 foot is the largest uncollapsed cross-section that will fit in the Shuttle cargo bay) is that of ease of initial on-orbit construction and preintegration of utility lines and subsystems. The primary rational for considering the 15 foot erectable truss is that the truss bay size will accommodate Shuttle size payloads and growth of the initial station in any dimension is a simple extension of the initial construction process. The primary rational for considering the double-fold 10 foot tetrahedral truss is that a relatively large amount of truss structure can be deployed from a single Shuttle flight to provide a large number of nodal attachments which present a pegboard for attaching a wide variety of payloads. The 15 foot double-fold PACTRUSS was developed to incorporate the best features of the erectable truss and the tetrahedral truss. B.W.

N85-33513*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
THE GALELEO SPACECRAFT MAGNETOMETER BOOM
D. T. PACKARD and M. D. BENTON (ACE-Able Engineering, Goleta, Calif.) *In* NASA. Ames Research Center 19th Aerospace Mech. Symp. p 1-22 Aug. 1985 refs
Avail: NTIS HC A17/MF A01 CSCL 20K

The Galileo spacecraft utilizes a deployable lattice boom to position three science instruments at remote distances from the spacecraft body. An improved structure and mechanism to precisely control deployment of the boom, and the unique deployment of an outer protective cover are described. Author

N85-35416 California Inst. of Tech., Pasadena.
STRUCTURAL ANALYSIS OF IMPERFECT THREE-LEGGED TRUSS COLUMNS FOR LARGE SPACE STRUCTURES APPLICATIONS Ph.D. Thesis
D. ELYADA 1985 198 p
Avail: Univ. Microfilms Order No. DA8508458

Three-legged truss columns are basic structural components of many envisioned large outer-space structures. They constitute three longerons (legs) forming, in the column cross-section, the vertices of an equilateral triangle. Their longerons are held together by uniformly spaced battens while a shear web, usually made of diagonals, restrains shear deformation. This work deals with configurations characterized by having relatively stiff battens, longerons which are pinned to the battens and prestressed string diagonals. Considered are only simple-supported slender columns having slender longeron segments and relatively thin and lightly preloaded diagonals. The columns are allowed to have global (overall) as well as local (longeron segment) geometrical imperfections--not necessarily small ones. Investigated is the static structural behavior of such columns when loaded by purely axial compressive concentrated forces acting at the supports.
Dissert. Abstr.

04

THERMAL CONTROL

Includes descriptions of analytical techniques, passive and active thermal control techniques, external and internal thermal experiments and analyses and trade studies of thermal requirements.

A85-30262*# Old Dominion Univ., Norfolk, Va.
FINITE ELEMENT THERMAL-STRUCTURAL ANALYSES OF A CABLE-STIFFENED ORBITING ANTENNA
E. A. THORNTON, P. DECHAUMPHAI (Old Dominion University, Norfolk, VA), and A. K. PANDEY (Virginia Polytechnic Institute and State University, Blacksburg, VA) IN: Structures, Structural Dynamics, and Materials Conference, 26th, Orlando, FL, April 15-17, 1985, Technical Papers. Part 1 . New York, American Institute of Aeronautics and Astronautics, 1985, p. 308-315. USAF-NASA-supported research. refs
(AIAA PAPER 85-0693)

Finite element thermal-structural analyses of a cable-stiffened orbiting antenna are presented. The determination of prestresses in the antenna is described first. Heating and thermal analyses for orbiting space structures are then discussed briefly. Structural deformations and stresses are presented for three finite element structural analysis approaches: (1) small deflections, (2) stress-stiffening, and (3) large deflections. The accuracy of the three analysis approaches is evaluated for the orbiting antenna at different prestress levels. Author

A85-33003
RF-TRANSPARENT SOLAR SHIELD
A. E. MASON, E. B. MURPHY, D. M. NATHANSON, and M. S. POWELL (MIT, Lexington, MA) SAMPE Quarterly (ISSN 0036-0821), vol. 16, April 1985, p. 14-17.

A new design for an opaque barrier to the sun's space radiation is proposed, which uses a series of Kapton film envelopes sandwiching thin quartz paper. The structure is intended to function as a radome in receiving and transmitting high-frequency communication signals with minimal thermal, optical, and dielectric effects on the satellite structures. Simulation tests revealed the heat flow from the satellite interior to be 3.2 W/sq ft, and 5.2 W/sq ft for the case of solar illumination. To protect the dielectric materials from space radiation indium tin oxide film is deposited

on the substrate, with no significant impairment to the RF transmission. L.T.

A85-33716
FUNCTIONAL TEST PERFORMANCE OF TDM ADVANCED HEAT REJECTION SYSTEM IN VACUUM
P. MESSIDORO, P. BURATTI (Aeritalia S.p.A., Turin, Italy), and B. AALDERS (ESA, European Space Research and Technology Centre, Noordwijk, Netherlands) AIAA, SAE, ASME, AIChE, and ASMA, Intersociety Conference on Environmental Systems, 14th, San Diego, CA, July 16-19, 1984. 13 p. Research supported by the European Space Agency. refs
(SAE PAPER 840962)

A technology demonstration model of an advanced heat rejection system is presented, developed to satisfy two general categories of spacecraft: the Spacelab and its derivatives, which require heat rejection of 2 to 10 kW and which vary from 7 to 60 days in duration; and space platforms and stations, which require heat rejection of 2-25 kW and last for several years. The model consists of a fluid loop comprising two radiator panels and two thermal control valves for temperature regulation in the panels. The system was tested in the vacuum chamber, showing heat rejection capability higher than predicted theoretically and meeting all other requirements. L.T.

A85-33717
EURECA THERMAL CONTROL SUBSYSTEM CONCEPT
L. COSTAMAGNA and G. BRAMBATI (Aeritalia S.p.A., Turin, Italy) AIAA, SAE, ASME, AIChE, and ASMA, Intersociety Conference on Environmental Systems, 14th, San Diego, CA, July 16-19, 1984. 8 p.
(SAE PAPER 840963)

The thermal control design concept for the European Reusable Carrier (EURECA), scheduled to be placed in orbit by the Space Shuttle in 1987, is presented, with a description of the mission profile and thermal control system requirements. The control is a combination of active (fluid loop) and passive sections supplemented by a heater and temperature sensor system. The plumbing, insulation, and radiator panel designs are detailed as well. It is concluded that the EURECA thermal control subsystem is capable of accommodating a large variety of payloads with a total payload dissipation of up to 1.7 kW, satisfying simultaneously the temperature limits of the subsystem equipment. L.T.

A85-33726* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
SPACE-CONSTRUCTIBLE HEAT PIPE RADIATOR THERMAL VACUUM TEST PROGRAM
P. F. MARSHALL (NASA, Johnson Space Center, Houston, TX) AIAA, SAE, ASME, AIChE, and ASMA, Intersociety Conference on Environmental Systems, 14th, San Diego, CA, July 16-19, 1984. 13 p.
(SAE PAPER 840973)

The thermal vacuum test program being carried out at the Johnson Space Center on two prototype radiator elements intended for use in future large space platforms is discussed. The test program is described, as are the test articles, including the radiator element, evaporator assemblies, mechanical interface unit, contact heat exchanger assembly, tilt table mechanism, and supports. Test results on the heat pipe performance, radiator element performance, freeze/thaw characteristics, and contact heat exchanger assembly mechanism are discussed. It is concluded that the fundamental design goals for the radiator subsystem have been met. C.D.

A85-33727
CONCEPTUAL DESIGN OF A THERMAL BUS FOR LARGE SPACE PLATFORMS
F. EDELSTEIN and R. BROWN (Grumman Aerospace Corp., Bethpage, NY) AIAA, SAE, ASME, AIChE, and ASMA, Intersociety Conference on Environmental Systems, 14th, San Diego, CA, July 16-19, 1984. 14 p. refs
(SAE PAPER 840975)

Evolving future space platforms will require a more significant role of thermal management as a result of the multi-year mission durations, large quantities of waste heat, longer physical distances, and a variety of payloads which must be accommodated by the platform. A viable concept in thermal management is a two-phase fluid loop system that transfers heat by evaporation and condensation, thereby operating at a constant temperature over the entire length of the loop. A number of concepts for a two-phase thermal bus have been investigated; these involved series and parallel configurations, both with and without mechanical pumps. Evaluation of these concepts based on weight, thermal characteristics, ground testability, reliability/complexity, growth capability, and development risk resulted in the recommendation of a parallel flow/modulating valve concept. Author

A85-33729
ANALYTICAL APPROACH AND COMPUTER MODEL DEVELOPMENT FOR PERFORMANCE INVESTIGATIONS OF LIQUID DROPLET RADIATORS
B. BRANDELL (McDonnell Douglas Astronautics Co., Huntington Beach, CA) AIAA, SAE, ASME, AIChE, and ASMA, Intersociety Conference on Environmental Systems, 14th, San Diego, CA, July 16-19, 1984. 9 p.
(SAE PAPER 840977)

The liquid droplet radiator (LDR) affords lighter weight for high-power (greater than 100 kilowatt) spacecraft by eliminating the solid radiating surface. This is accomplished by shooting a droplet sheet of radiator fluid from an ejector to a collector thus allowing the fluid to radiate directly to space. The volumetric nature of the radiative transfer introduces added complexity in the thermal analysis of the LDR. Key performance information for LDR designs, such as interior droplet sheet temperature distribution and local heat flux, cannot be determined by assigning an effective emissivity and absorptivity to the sheet. An analysis and computer model has been developed which realistically models the nature of the radiative exchange by determining volumetric interchange factors using ray tracing and a Monte Carlo technique. The computer analysis returns sheet temperature distribution and heat rejection information for a rectangular-shaped droplet sheet with specified optical depth and ejector and collector temperatures. Author

A85-33731
LARGE SPACECRAFT AND RELATED VERIFICATION ASPECTS OF THE THERMAL DESIGN
J. WEYDANDT and K. BECKMANN (ERNO Raumfahrttechnik GmbH, Bremen, West Germany) AIAA, SAE, ASME, AIChE, and ASMA, Intersociety Conference on Environmental Systems, 14th, San Diego, CA, July 16-19, 1984. 17 p. Research sponsored by the European Space Agency and International Telecommunications Satellite Organization. refs
(SAE PAPER 840979)

The most often utilized method of thermal design verification for past and current types of spacecraft has been by Solar Thermal Vacuum (STV) tests at system level. This approach, however, will require fundamental modifications for future large and complex spacecraft, three types of which are defined: a large communication satellite, a modular earth observation satellite and a large infrared telescope, all exceeding the capabilities of existing STV test facilities. A trade-off is made between analysis only and analysis plus test, considering the influence of temperature limits, analysis uncertainty and correlation of analysis and test, as well as indicating the ways in which it affects the thermal design verification. Alternative test methods - STV testing in parts, infrared radiation tests, thermal canister method, skin heater application - are also discussed with regard to their advantages and disadvantages of

applying them to the large types of spacecraft. The thermal design considerations to be regarded and the critical parameters to be verified by test are highlighted, in order to enable the alternative verification test concept at an acceptable level of confidence. The test concepts for the large spacecraft are described briefly.
Author

A85-33761
MONOGROVE HEAT PIPE RADIATOR SHUTTLE FLIGHT EXPERIMENT DESIGN, ANALYSIS, AND TESTING
J. P. ALARIO (Grumman Aerospace Corp., Bethpage, CA) AIAA, SAE, ASME, AIChE, and ASMA, Intersociety Conference on Environmental Systems, 14th, San Diego, CA, July 16-19, 1984. 9 p. refs
(SAE PAPER 840950)

This paper reports the design and performance of the NASA/Grumman heat pipe radiator experiment which was successfully flown on Shuttle flight STS-8. It was the first zero-g demonstration of the high-capacity monogroove heat pipe concept which NASA is planning to use in its space constructible radiator system for future large Space Stations. The subscale 1.85-m-long U-shaped test article used Freon-21 working fluid and was configured with a double-sided radiator for heat rejection and electrical heaters for heat input. It was operated in the Shuttle payload bay environment for over 2 hours under a 70-watt sustained load. A unique feature of this experiment was the use of temperature-sensitive liquid crystal film to monitor thermal response by astronaut observation of color changes. Author

A85-37165* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
SPACE STATION ACTIVE THERMAL CONTROL TECHNICAL CONSIDERATIONS
W. E. ELLIS (NASA, Johnson Space Center, Systems Engineering Branch, Houston, TX) IN: New opportunities in space; Proceedings of the Twenty-first Space Congress, Cocoa Beach, FL, April 24-26, 1984 . Cape Canaveral, FL, Canaveral Council of Technical Societies, 1984, p. 5-9 to 5-24. refs

A description of recent and planned thermal control technology developments at the Johnson Space Center and the other NASA Centers in support of Space Stations is presented. The program is centered around satisfying the needs of the users. Preliminary results of proof-of-concept high capacity heat pipes and two-phase devices are included which indicate that large amounts of energy (100 kW) can be transported long distances (50 m) with very small temperature differences. The presentation summarizes preparations for an 'evolutionary test bed' for advanced development of thermal technology which will provide data on components and systems for incorporation into the Space Station designs in the late 1980s. The results of the recently flown Heat Pipe Experiment aboard STS-8 are presented. Author

A85-37587#
DESIGN AND TEST OF A TWO-PHASE MONOGROOVE COLD PLATE
F. EDELSTEIN, R. BROWN, and K. KOUBEK (Grumman Corp., Bethpage, NY) American Institute of Aeronautics and Astronautics, Thermophysics Conference, 20th, Williamsburg, VA, June 19-21, 1985. 9 p.
(AIAA PAPER 85-0918)

A two-phase cold plate has been designed, fabricated, and tested as a candidate heat acquisition component in a two-phase Space Station thermal management system. Derived from the high flux monogroove heat pipe, the cold plate provides fine grooved surfaces from which evaporation occurs. Subcooled liquid enters the plate from a pumped supply in response to a valve that is controlled by an ultrasonic sensor that detects liquid inventory. Essentially, single phase vapor exits the plate. While Freon-11 or ammonia could be used as the working fluid, initial testing has been done with Freon-11. Stable heat loads of 4.0 kW (0.88 W/sq cm) have been achieved with uniform heat input to the 0.58 by 0.87m aluminum cold plate. Nonuniform loads of 3.5kW (1.5 W/sq cm) have also been achieved over half the plate area. Temperatures on the plate mounting surface have been relatively uniform, with a standard deviation of + or - 2.2C at a flux level of 0.76 W/sq cm. Under these conditions, the temperature drop between the plate and vapor was 4.2C. A small amount of liquid carryover evident in the exit vapor stream was measured to be less than 2 percent of mass flow. Author

A85-37588*# McDonnell-Douglas Astronautics Co., St. Louis, Mo.
DESIGN AND TEST OF A PUMPED TWO-PHASE MOUNTING PLATE
M. G. GROTE (McDonnell Douglas Astronautics Co., St. Louis, MO) and T. D. SWANSON (NASA, Goddard Space Flight Center, Greenbelt, MD) American Institute of Aeronautics and Astronautics, Thermophysics Conference, 20th, Williamsburg, VA, June 19-21, 1985. 9 p.
(Contract NAS5-27765)
(AIAA PAPER 85-0919)

The design, fabrication, and testing of the full-scale development unit of a pumped two-phase mounting plate (TPMP) used in advanced two-phase spacecraft thermal control systems are described. The mounting plate is tested with R-11 in the evaporator mode for total heat loads of over 3000 watts and local heat fluxes over 4 W/sq cm, and in the condenser mode with condenser loads from 60 to 400 watts and inlet qualities from 8 to 94 percent. The calculated heat-transfer coefficients are between 0.66 and 1.0 W/sq cm/C and are nearly independent of the flow rate and heat load except at very low heat loads. It is shown that the TPMP can be run with inlet conditions down to 22 C subcooling without any significant gradients in the plate and that it performs well with nonuniform heat fluxes. M.D.

A85-37589*# Sundstrand Corp., Rockford, Ill.
A SWIRL FLOW EVAPORATIVE COLD PLATE
R. E. NIGGEMANN, W. J. GREENLEE, D. G. HILL (Sundstrand Corp., Advanced Technology Group, Rockford, IL), W. ELLIS, and P. MARSHALL (NASA, Johnson Space Center, Houston, TX) American Institute of Aeronautics and Astronautics, Thermophysics Conference, 20th, Williamsburg, VA, June 19-21, 1985. 25 p. refs
(Contract NAS9-17195)
(AIAA PAPER 85-0920)

A forced flow evaporative cold plate is under development for future application to the thermal bus concept being pursued by NASA for Space Station Thermal Control. The vaporizer is a swirl-flow device employing a spiral tube coil geometry sandwiched between conductive metal plates upon which electric components could be mounted. This concept is based on the inherent phase separation that occurs in a two phase stream in curvilinear flow. This is a zero 'g' design with one 'g' all-attitude capability and is capable of high heat transfer coefficients, good isothermality, and the ability to function at heat fluxes approaching 5w/sq cm on the cold plates (10w/sq cm on the tube wall) with Freon 114. The advantages of this design over other two phase evaporator approaches are high heat flux capability, simplified control requirements, insensitivity to micro-gravity oscillations, and inexpensive manufacturability. The program included design, fabrication, and test of such a cold plate utilizing an existing test stand developed for two-phase thermal management system (TPTMS) testing. Test results analysis and conclusions are included. Author

A85-37628*# Hughes Aircraft Co., Torrance, Calif.
HONEYCOMB PANEL HEAT PIPE DEVELOPMENT FOR SPACE RADIATORS
H. J. TANZER, G. L. FLEISCHMAN (Hughes Aircraft Co., Torrance, CA), and J. G. RANKIN (NASA, Johnson Space Center, Houston, TX) American Institute of Aeronautics and Astronautics, Thermophysics Conference, 20th, Williamsburg, VA, June 19-21, 1985. 11 p. refs
(AIAA PAPER 85-0978)

An assessment of the honeycomb panel heat pipe concept as a moderate temperature range, low-mass, highly efficient radiator

fin for the NASA Space Station is presented, based on test results for a thin-wall (0.46 mm) all-welded stainless steel sample with core depth of 63.5 mm and a hexagonal-cell size of 127.7 mm. The 0.61 x 3.05 m test segment, operating with methanol as a working fluid, exhibited a maximum heat transfer rate of 600 W at 50 C and was isothermal to within + or - 2 C almost entirely throughout the surface. Tilt testing, which comprised relocation of the heater along one edge of the panel, resulted in maximum power levels of 70 and 50 W at panel elevations of 12.7 and 25.4 mm, respectively. As-designed panel performance is predicted to be from 500 to 1000 W over the range of operating temperatures; better performance is predicted for an open-channel design. L.T.

A85-37651#
NONSTEADY TEMPERATURE DISTRIBUTION IN SOLIDS USING THE OPTIMIZATION PRINCIPLES
A. M. SHARAN (Newfoundland, Memorial University, St. Johns, Canada) and B. S. REDDY American Institute of Aeronautics and Astronautics, Thermophysics Conference, 20th, Williamsburg, VA, June 19-21, 1985. 7 p.
(AIAA PAPER 85-1015)

The transient temperature distribution within a solid subjected to nonlinear boundary conditions have been obtained using the finite element method. The conduction and the capacitance matrices have been evaluated as a function of temperature due to the nonlinearity in the material properties of the solid. The nonlinear algebraic equations are solved using the variable metric method and an iteration technique. The results indicate that the variable metric method can be a useful tool in solving nonlinear heat transfer problems. Author

A85-37658*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
THERMAL DESIGN OF THE ACCESS ERECTABLE SPACE TRUSS
O. H. BRADLEY, JR. and R. A. FOSS (NASA, Langley Research Center, Systems Engineering Div., Hampton, VA) American Institute of Aeronautics and Astronautics, Thermophysics Conference, 20th, Williamsburg, VA, June 19-21, 1985. 10 p. refs
(AIAA PAPER 85-1024)

Thermal design requirements for the erectable truss beam to be assembled in-orbit during extra-vehicular activity as part of the ACCESS experiment to take place in 1985-1986 are formulated and assessed. The coatings, insulation, and materials chosen for the structural elements of the beam are detailed. A combined radiation and conduction thermal model reveals that worst-case thermal gradients within the ACCESS structure over plane-to-sun angles of 0 to 80 deg will be less than 29 F, which is within the allowable limit of 50 F. The individual strut insulation concept using aluminized Kapton is shown to offer significant advantages over white paint or a chromic acid anodized surface for controlling the thermal response. L.T.

A85-37666*# Rockwell International Corp., Seal Beach, Calif.
THERMAL MANAGEMENT SYSTEM OPTIONS FOR HIGH POWER SPACE PLATFORMS
J. A. SADUNAS, A. LEHTINEN (Rockwell International Corp., Satellite Systems Div., Seal Beach, CA), and R. PARISH (NASA, Johnson Space Center, Houston, TX) American Institute of Aeronautics and Astronautics, Thermophysics Conference, 20th, Williamsburg, VA, June 19-21, 1985. 17 p. refs
(Contract NAS9-16782)
(AIAA PAPER 85-1047)

Thermal Management System (TMS) design options for a high power (75kWe), low earth orbit, multimodule space platform were investigated. The approach taken was to establish a baseline TMS representative of current technology, and to make incremental improvements through successive subsystem trades that lead to a candidate TMS. The TMS trades included centralized and decentralized transport, single-phase and two-phase transport, alternate working fluids, liquid loop and heat pipe radiators, deployed fixed, body mounted and steerable radiators, and thermal storage. The subsystem options were evaluated against criteria such as weight, TMS power requirement, reliability, system isothermality penalty, and growth potential. Author

A85-37667#
SPACE CONSTRUCTIBLE RADIATOR ON-ORBIT ASSEMBLY
P. J. OTTERSTEDT, J. HUSSEY, and J. P. ALARIO (Grumman Aerospace Corp., Bethpage, NY) American Institute of Aeronautics and Astronautics, Thermophysics Conference, 20th, Williamsburg, VA, June 19-21, 1985. 6 p.
(AIAA PAPER 85-1048)

This paper discusses the most recent approaches for the on-orbit assembly of the Space Constructible Radiator system (SCR) being developed for NASA's space station. Conceptual designs of suitable grappling hardware, radiator panel configurations, and insertion techniques are evaluated. Initial ground simulation results are presented using a six-degree-of-freedom (6-DOF) Shuttle Remote Manipulator System (SRMS) simulator, both with and without force feedback. Radiator insertion in a close-tolerance rectangular opening has been achieved, without force feedback, using a special alignment target. Author

A85-37669#
A CONCEPT OF FLUID DYNAMIC HEAT REJECTING SYSTEM FOR LARGE SCALE SPACE STATION
Y. KOBAYASHI (Tsukuba, University, Sakura, Ibaraki, Japan) American Institute of Aeronautics and Astronautics, Thermophysics Conference, 20th, Williamsburg, VA, June 19-21, 1985. 8 p. refs
(AIAA PAPER 85-1051)

A new type of fluid dynamic heat rejecting system employing heat pipe heat rejector (HPHR) is proposed for a future large scale space station which will dissipate more than 100 kilowatts of heat energy in space. One of the significant features of this system is that it works both as a radiator and a refrigerator depending on the thermal environment of the spacecraft. Another feature is that the system can operate at relatively low pressure ranges of less than 1.0 MPa by selecting a suitable working fluid, since its thermodynamic cycle is composed of two adiabatic and two constant-volume changes under a vapor-liquid coexisting condition. This fact will result in a high coefficient of performance (COP) and simpleness of structural design. To verify the correctness of this concept, a simple laboratory model of HPHR was manufactured and demonstrated its cooling capability. Author

A85-37674*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
AEROTHERMODYNAMIC HEATING AND PERFORMANCE ANALYSIS OF A HIGH-LIFT AEROMANEUVERING AOTV CONCEPT
G. P. MENEES, K. G. BROWN (NASA, Ames Research Center, Moffett Field, CA), J. F. WILSON, and C. B. DAVIES (Informatics General Corp., Palo Alto, CA) American Institute of Aeronautics and Astronautics, Thermophysics Conference, 20th, Williamsburg, VA, June 19-21, 1985. 11 p. refs
(AIAA PAPER 85-1060)

The thermal-control requirements for design-optimized aeromaneuvering performance are determined for space-based applications and low-earth orbit sorties involving large, multiple plane-inclination changes. The leading-edge heating analysis is the most advanced developed for hypersonic-rarefied flow over lifting surfaces at incidence. The effects of leading-edge bluntness, low-density viscous phenomena, and finite-rate flow-field chemistry and surface catalysis are accounted for. The predicted aerothermodynamic heating characteristics are correlated with thermal-control and flight-performance capabilities. The mission payload capability for delivery, retrieval, and combined operations is determined for round-trip sorties extending to polar orbits. Recommendations are given for future design refinements. The results help to identify technology issues required to develop prototype operational systems. Author

A85-37683#
DEVELOPMENT OF LARGE SCALE THERMAL LOUVER
K. TANAKA, G. FUJII, and T. MACHIDA (NEC Corp., Yokohama, Japan) American Institute of Aeronautics and Astronautics, Thermophysics Conference, 20th, Williamsburg, VA, June 19-21, 1985. 8 p.
(AIAA PAPER 85-1075)

The development of a 0.9 m x 0.9 m x 0.07 m size thermal louver which is designed and fabricated to be applied to a large 3-axis stabilized satellite circling the earth's orbit is described. In order to enlarge and lighten the louver, an investigation of the satellite's mission requirements, configuration, size, orbit, and attitude control system is performed. The tests conducted to evaluated the louver's thermal and mechanical performances, which are found to exceed those of comparable conventional louvers, are presented. It is shown that excellent agreement exists between the thermal performance obtained from the thermal vacuum test and the analytical value, and that the louver exhibits no functional abnormalities after random vibration tests. M.D.

A85-37686#
LOW TEMPERATURE EXPANDABLE MEGAWATT PULSE POWER RADIATOR
L. C. CHOW (Washington State University, Pullman, WA), E. T. MAHEFKEY, and J. E. YOKAJTY (USAF, Aero Propulsion Laboratory, Wright-Patterson AFB, OH) American Institute of Aeronautics and Astronautics, Thermophysics Conference, 20th, Williamsburg, VA, June 19-21, 1985. 12 p. refs
(Contract F49620-82-C-0035)
(AIAA PAPER 85-1078)

A feasibility study of a novel light-weight, low-temperature, expandable pulse power radiator was carried out. The radiator has a large volume to surface-area ratio and is functionally capable to act as a waste heat storage reservoir and to reject average power during the on- and off-peak period. The dynamic behavior of the radiator subject to some hypothetical duty cycles is predicted. The potential problem of damages caused by micrometeoroids is assessed. Two possible deployment/retraction mechanisms are suggested. It is concluded that the present radiator concept is a sound one and should be further developed. Suggestions for future research are offered. Author

A85-39259
A TWO-PHASE THERMAL MANAGEMENT SYSTEM FOR THE SPACE STATION
T. J. BLAND, R. S. DOWNING, and D. P. ROGERS (Sundstrand Corp., Sundstrand Advanced Technology Group, Rockford, IL) IN: Space systems technology; Proceedings of the Aerospace Congress and Exposition, Long Beach, CA, October 15-18, 1984 . Warrendale, PA, Society of Automotive Engineers, Inc. (SAE SP-593), 1984, p. 85-91. refs
(SAE PAPER 841525)

The central thermal management system for the proposed NASA Space Station will likely employ a two-phase thermal bus to satisfy the high power and long transport distance requirements. Significant potential weight and power savings accrue from this approach. A pumped two-phase cooling loop is described that can meet the requirements while maintaining constant heat source temperatures with large power and sink temperature turndown capability. Predicted performance of the 25 kW ammonia flight conceptual design is presented along with test results from a Freon 114 test loop which confirms predicted characteristics. Author

A85-41341*# Thermacore, Inc., Lancaster, Pa.
HIGH PERFORMANCE FLEXIBLE HEAT PIPES
R. M. SHAUBACH and N. J. GERNERT (Thermacore, Inc., Lancaster, PA) AIAA, Thermophysics Conference, 20th, Williamsburg, VA, June 19-21, 1985. 7 p.
(Contract NAS9-17036)
(AIAA PAPER 85-1085)

A Phase I SBIR NASA program for developing and demonstrating high-performance flexible heat pipes for use in the thermal management of spacecraft is examined. The program combines several technologies such as flexible screen arteries and high-performance circumferential distribution wicks within an envelope which is flexible in the adiabatic heat transport zone. The first six months of work during which the Phase I contract goal were met, are described. Consideration is given to the heat-pipe performance requirements. A preliminary evaluation shows that the power requirement for Phase II of the program is 30.5 kilowatt meters at an operating temperature from 0 to 100 C. M.D.

A85-42910*# Old Dominion Univ., Norfolk, Va.
THERMAL-STRUCTURAL ANALYSIS OF LARGE SPACE STRUCTURES - AN ASSESSMENT OF RECENT ADVANCES
E. A. THORNTON (Old Dominion University, Norfolk, VA) and D. B. PAUL (USAF, Flight Dynamics Laboratory, Wright-Patterson AFB, OH) (Structures, Structural Dynamics and Materials Conference, 24th, Lake Tahoe, NV, May 2-4, 1983, Collection of Technical Papers. Part 1, p. 683-696) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 22, July-Aug. 1985, p. 385-393. USAF-NASA-supported research. Previously cited in issue 12, p. 1741, Accession no. A83-29800. refs

N85-23907# European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk (Netherlands). Space Science Dept.
CONTACTLESS DETERMINATION OF THE CONDUCTIVITY OF THE WHITE PAINT PCB-Z
H. ARENDS and R. SCHMIDT *In* ESA. The Giotto Spacecraft Impact-Induced Plasma Environ. p 11-14 Sep. 1984 refs
Avail: NTIS HC A06/MF A01

A method to measure the conductivity of the white paint used on the Giotto spacecraft dust shield was developed for use in a model of spacecraft/plasma interaction during Halley's comet fly-by. The method measures conductivity without mechanical contacts in vacuo. Painted targets were exposed to a beam of low energy electrons. The current through the target was measured at different bias potentials. The current-voltage characteristics of painted samples were compared with one of an aluminum anode of identical dimensions. The differences between the characteristics for aluminum and paint are used to derive resistances at a given potential drop through the barely conductive top coat. An average resistivity of 10 billion ohmcm, area resistance of 10 million ohm/sqcm, and sheet resistance of 10 to the 13th power ohm are obtained. Author (ESA)

N85-28963# Old Dominion Univ., Norfolk, Va. Dept. of Mechanical Engineering and Mechanics.
FINITE ELEMENT THERMAL-STRUCTURAL ANALYSIS OF CABLE-STIFFENED SPACE STRUCTURES Final Report, 1 Jun. - 31 Dec. 1982
E. A. THORNTON and A. K. PANDY Wright-Patterson AFB, Ohio AFWAL Oct. 1984 107 p
(Contract F33615-82-K-3219)
(AD-A153822; AFWAL-TR-84-3079) Avail: NTIS HC A06/MF A01 CSCL 22A

Finite element thermal-structural analyses of cable-stiffened space structures are presented. A computational scheme for calculation of prestresses in the cable-stiffened structures is also described. The determination of thermal loads on orbiting space structures due to environmental heating is described briefly. Three finite element structural analysis techniques are presented for the analysis of prestressed structures. Linear, stress stiffening and large displacement analysis techniques are investigated. The three techniques are employed for analysis of prestressed cable structures at different prestress levels. The analyses produce similar results at small prestress but at higher prestress, differences between the results become significant. For the cable-stiffened structures studied, the linear analysis technique may not provide acceptable results. The stress stiffening analysis technique may yield results of acceptable accuracy depending on the prestress. The large displacement analysis technique produces accurate results over a wide range of prestresses and is recommended as

a general analysis technique for thermal-structural analysis of cable-stiffened space structures. Author (GRA)

05

ENVIRONMENTAL CONTROL AND LIFE SUPPORT SYSTEMS

Includes description of analytical techniques and models, trade studies of technologies, subsystems, support strategies, and experiments for internal and external environmental control and protection, life support systems, human factors, life sciences and safety.

A85-22522
BICYCLE ERGOMETRY TESTING IN THE DIAGNOSIS OF CORONARY HEART DISEASE IN WOMEN IN COMPARISON WITH SELECTIVE CORONARY ANGIOGRAPHY DATA [VELOERGOMETRICHESKAIA PROBA V DIAGNOSTIKE ISHEMICHESKOI BOLEZNI SERDTSA U ZHENSHCHIN /SRAVNENIE S DANNYMI SELEKTIVNOI KORONAROANGIOGRAFII/]
B. A. SIDORENKO, A. A. LIAKISHEV, N. M. AKHMEDZHANOV, L. S. MATVEEVA, V. P. MAZAEV, and A. M. KRASNOSELSKII (Akademiia Meditsinskikh Nauk SSSR, Institut Klinicheskoi Kardiologii, Moscow, USSR) Kardiologiia (ISSN 0022-9040), vol. 24, Sept. 1984, p. 62-68. In Russian. refs

A85-32769
BIOLOGICAL STUDIES ON THE SALYUT ORBITAL STATIONS [BIOLOGICHESKIE ISSLEDOVANIIA NA ORBITAL'NYKH STANTSIIAKH 'SALIUT']
N. P. DUBININ, ED. Moscow, Izdatel'stvo Nauka, 1984, 262 p. In Russian. No individual items are abstracted in this volume.

Results of biological experiments performed on the Salyut stations are presented. Particular emphasis is placed on: scientific equipment and conditions for conducting biological experiments on scientific orbital stations; the effect of space flight factors on biopolymers and prebiological matter; experiments with lower and higher plants; experiments with animal cell cultures; studies with insects; experiments with vertebrates; the biological effect of heavy particles of galactic cosmic rays; and ground-based simulation experiments and test systems for the analysis of the biological effects of space flight. B.J.

A85-33711* Hamilton Standard, Windsor Locks, Conn.
ENVIRONMENTAL CONTROL AND LIFE SUPPORT SYSTEM ANALYSIS TOOLS FOR THE SPACE STATION ERA
R. L. BLAKELY (United Technologies Corp., Hamilton Standard Div., Windsor Locks, CT) and L. F. ROWELL (NASA, Langley Research Center, Hampton, VA) AIAA, SAE, ASME, AIChE, and ASMA, Intersociety Conference on Environmental Systems, 14th, San Diego, CA, July 16-19, 1984. 16 p.
(SAE PAPER 840956)

This paper describes the concept of a developing emulation, simulation, sizing, and technology assessment program (ESSTAP) which can be used effectively for the various functional disciplines (structures, power, ECLSS, etc.) beginning with the initial system selection and conceptual design processes and continuing on through the mission operation and growth phases of the Space Station for the purpose of minimizing overall program costs. It will discuss the basic requirements for these tools, as currently envisioned for the Environmental Control and Life Support System (ECLSS), identifying their intended and potential uses and applications, and present examples and status of several representative tools. The development and applications of a Space Station Atmospheric Revitalization Subsystem (ARS) demonstration model to be used for concent verification will also be discussed. Author

A85-33712* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
MANNED SPACE STATION ENVIRONMENTAL CONTROL AND LIFE SUPPORT SYSTEM COMPUTER-AIDED TECHNOLOGY ASSESSMENT PROGRAM
J. B. HALL, JR., S. J. PICKETT (NASA, Langley Research Center, Hampton, VA), and K. H. SAGE (Kentron International, Inc., Hampton, VA) AIAA, SAE, ASME, AIChE, and ASMA, Intersociety Conference on Environmental Systems, 14th, San Diego, CA, July 16-19, 1984. 19 p. refs
(SAE PAPER 840957)

A computer program for assessing manned space station environmental control and life support systems technology is described. The methodology, mission model parameters, evaluation criteria, and data base for 17 candidate technologies for providing metabolic oxygen and water to the crew are discussed. Examples are presented which demonstrate the capability of the program to evaluate candidate technology options for evolving space station requirements. C.D.

A85-33713* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
AIR REVITALIZATION SYSTEM INTEGRATION
P. D. QUATTRONE (NASA, Ames Research Center, Advanced Life Support Office, Moffett Field, CA), F. H. SCHUBERT, and D. B. HEPPNER (Life Systems, Inc., Cleveland, OH) AIAA, SAE, ASME, AIChE, and ASMA, Intersociety Conference on Environmental Systems, 14th, San Diego, CA, July 16-19, 1984. 10 p. refs
(SAE PAPER 840959)

This paper presents a status review of Spacecraft Air Revitalization System (ARS) integration using regenerable techniques. The paper addresses concepts of integration of individual subsystems into an Air Revitalization System, as well as integration of components within subsystems. An ARS design is presented based on the Electrochemical Depolarized Carbon Dioxide Concentrator Subsystem, the Sabatier Carbon Dioxide Reduction Subsystem, the Static Feed Water Electrolysis Subsystem, a condensing Humidity Control Subsystem, and a Water Handling Subsystem to perform the functions of CO2 removal, CO2 reduction, O2 generation, humidity control and by-product water distribution, respectively. The paper also highlights the numerous advantages of this integration. Trace contaminant control and the nitrogen supply are not included in the ARS described in this paper. Author

A85-33715* Hamilton Standard, Windsor Locks, Conn.
SPACE STATION ENVIRONMENTAL CONTROL AND LIFE SUPPORT SYSTEM ARCHITECTURE - CENTRALIZED VERSUS DISTRIBUTED
A. M. BOEHM (United Technologies Corp., Hamilton Standard Div., Windsor Locks, CT) and A. F. BEHREND (NASA, Johnson Space Center, Houston, TX) AIAA, SAE, ASME, AIChE, and ASMA, Intersociety Conference on Environmental Systems, 14th, San Diego, CA, July 16-19, 1984. 11 p. refs
(SAE PAPER 840961)

Both Centralized and Distributed approaches are being evaluated for the installation of Environmental Control and Life Support (ECLS) equipment in the Space Station. In the Centralized facility concept, integrated processing equipment is located in two modules with plumbing used to circulate ECLS services throughout the Station. The Distributed approach locates the ECLS subsystems in every module of the Space Station with each subsystem designed to meet its own module needs. This paper defines the two approaches and how the advantages and disadvantages of each are tied to the choice of Space Station architecture. Other considerations and evaluations include: crew movement, Station evolution and the ducting impact needed to circulate ECLS services from centrally located processing equipment. Author

A85-33732* Hamilton Standard, Windsor Locks, Conn.
DEVELOPMENT OF A ZERO-PREBREATHE SPACESUIT
C. W. FLUGEL (United Technologies Corp., Hamilton Standard Div., Windsor Locks, CT), J. J. KOSMO (NASA, Johnson Space Center, Houston, TX), and J. R. RAYFIELD (ILC Industries, Inc., ILC Dover, Frederica, DE) AIAA, SAE, ASME, AIChE, and ASMA, Intersociety Conference on Environmental Systems, 14th, San Diego, CA, July 16-19, 1984. 13 p.
(SAE PAPER 840981)

This paper presents the results of a program to develop an improved high pressure (zero-prebreathe) spacesuit utilizing the latest joint technology as well as materials and processes which are consistent with the space environment and suit production techniques. Other development objectives include: longer life, lower joint torques with increased ranges, improved reproducibility and reliability, facilitated resizing ability and increased overall performance capability when compared to the present Shuttle Orbiter Spacesuit at the higher pressures. Author

A85-33741* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
SPACE STATION MEDICAL SCIENCES CONCEPTS
J. A. MASON and P. C. JOHNSON, JR. (NASA, Johnson Space Center, Houston, TX) AIAA, SAE, ASME, AIChE, and ASMA, Intersociety Conference on Environmental Systems, 14th, San Diego, CA, July 16-19, 1984. 8 p. Previously announced in STAR as N84-21040.
(SAE PAPER 840928)

Current life sciences concepts relating to Space Station are presented including the following: research, extravehicular activity, biobehavioral considerations, medical care, maintenance of dental health, maintaining health through physical conditioning and countermeasures, protection from radiation, atmospheric contamination control, atmospheric composition, noise pollution, food supply and service, clothing and furnishings, and educational program possibilities. Information on the current status of Soviet Space Stations is contained. Author

A85-33742* Hamilton Standard Div., United Aircraft Corp., Windsor Locks, Conn.
ECLS FOR THE NASA CDG SPACE STATION MODEL
R. J. CUSHMAN (United Technologies Corp., Hamilton Standard Div., Windsor Locks, CT) and G. ROBINSON (NASA, Washington, DC) AIAA, SAE, ASME, AIChE, and ASMA, Intersociety Conference on Environmental Systems, 14th, San Diego, CA, July 16-19, 1984. 10 p.
(SAE PAPER 840929)

This paper describes the approaches to Environmental Control and Life Support (ECLS) loop closure that have been studied for a permanently manned Space Station, by the NASA Concept Development Group (CDG) and industry. The paper explains the rationale behind the level of the loop closure chosen for ECLS expendables and why this level was chosen. The paper also explains potential synergistic interactions, between ECLS subsystems and other vehicle systems, which can lessen vehicle expendable penalties and help simplify required ECLS hardware, interfaces and control. Of particular significance are the potential interfacing of the ECLS subsystem which concentrates the metabolic CO2 removed from the atmosphere, with propulsion system resistojets and the use of cryogenic boiloff to satisfy crew metabolic needs. The paper shows the trade-offs that must be performed in order to make a selection from available options. Author

A85-33743* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
NASA'S PLANS FOR LIFE SCIENCES RESEARCH FACILITIES ON A SPACE STATION
R. ARNO, M. HEINRICH, and A. MASCY (NASA, Ames Research Center, Moffett Field, CA) AIAA, SAE, ASME, AIChE, and ASMA, Intersociety Conference on Environmental Systems, 14th, San Diego, CA, July 16-19, 1984. 9 p.
(SAE PAPER 840930)

A Life Sciences Research Facility on a Space Station will contribute to the health and well-being of humans in space, as well as address many fundamental questions in gravitational and developmental biology. Scientific interests include bone and muscle attrition, fluid and electrolyte shifts, cardiovascular deconditioning, metabolism, neurophysiology, reproduction, behavior, drugs and immunology, radiation biology, and closed life-support system development. The life sciences module will include a laboratory and a vivarium. Trade-offs currently being evaluated include (1) the need for and size of a 1-g control centrifuge; (2) specimen quantities and species for research; (3) degree of on-board analysis versus sample return and ground analysis; (4) type and extent of equipment automation; (5) facility return versus on-orbit refurbishment; (6) facility modularity, isolation, and system independence; and (7) selection of experiments, design, autonomy, sharing, compatibility, and integration. Author

A85-33744* National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
SPACE STATION ACCOMMODATION ENGINEERING FOR LIFE SCIENCES RESEARCH FACILITIES
J. HILCHEY (NASA, Marshall Space Flight Center, Huntsville, AL), E. GUSTAN (Boeing Aerospace Co., Seattle, WA), and C. E. RUDIGER (Lockheed Missiles and Space Co., Inc., Huntsville, AL) AIAA, SAE, ASME, AIChE, and ASMA, Intersociety Conference on Environmental Systems, 14th, San Diego, CA, July 16-19, 1984. 18 p. refs
(SAE PAPER 840931)

Exploratory studies conducted by NASA Marshall Space Flight Center and several contractors in connection with defining the design requirements, parameters, and tradeoffs of the Life Sciences Research Facilities for nonhuman test subjects aboard the Space Station are reviewed. The major system discriminators which determine the size of the accommodation system are identified, along with a number of mission options. Moreover, characteristics of several vivarium concepts are summarized, focusing on the cost, size, variable-g capability, and the number of specimens accommodated. Finally, the objectives of the phase B studies of the Space Station Laboratory, which are planned for FY85, are described. L.T.

A85-33745
HUMAN PRODUCTIVITY IN THE SPACE STATION PROGRAM - THE IMPACT OF THE ENVIRONMENTAL CONTROL AND LIFE SUPPORT SYSTEM
C. A. POYTHRESS (United Technologies Corp., Hamilton Standard Div., Windsor Locks, CT) AIAA, SAE, ASME, AIChE, and ASMA, Intersociety Conference on Environmental Systems, 14th, San Diego, CA, July 16-19, 1984. 8 p.
(SAE PAPER 840932)

The Environmental Control and Life Support (ECLS) System can be a major contributor to Space Station productivity through creative approaches to analysis and design, installation and maintenance. Emulation/simulation computer modeling can enhance ECLSS design, performance predictions and anomaly investigations. Innovative design approaches can yield an integrated ECLSS that provides a more manageable work package, improves ground processing and crew operations. Productivity can also be enhanced by proper attention to equipment design and integration, especially in terms of accessibility for maintenance and the selected level for on-orbit replacement. Author

A85-33746*
A NOVEL REVERSE-OSMOSIS WASH WATER RECYCLE SYSTEM FOR MANNED SPACE STATIONS
R. J. RAY, W. C. BABCOCK, R. P. BARSS, T. A. ANDREWS, and E. D. LACHAPELLE AIAA, SAE, ASME, AIChE, and ASMA, Intersociety Conference on Environmental Systems, 14th, San Diego, CA, July 16-19, 1984. 11 p. refs
(Contract NAS9-17031)
(SAE PAPER 840933)

The preliminary development of a wash water recycle system utilizing an inside-skinned hollow-fiber membrane is described. This module configuration is based on tube-side feed and is highly resistant to fouling with a minimum of pretreatment. During an ongoing research program for NASA, these modules were operated on actual wash waters with no significant fouling for a period of 40 days. Due to the tube-side-feed flow in these hollow-fiber membranes, the fibers themselves become the pressure vessels, allowing the development of extremely lightweight membrane modules. During the NASA research program, a pre-prototype membrane module capable of processing 6 gallons per day of wash water at 97 percent recovery was developed that can be dry-stored and that weighs 120 g. Author

A85-33758
SPACE STATION LIFE SCIENCES RESEARCH FACILITY TECHNOLOGY ASSESSMENT
T. C. SECORD and H. B. KELLY (McDonnell Douglas Astronautics Co., Huntington Beach, CA) AIAA, SAE, ASME, AIChE, and ASMA, Intersociety Conference on Environmental Systems, 14th, San Diego, CA, July 16-19, 1984. 12 p.
(SAE PAPER 840947)

The Space Station Life Science Research Facility (LSRF) Technology Assessment and Development Plan study for non-human research was performed for the NASA Ames Research Center. The primary objectives of the effort were to: (1) provide an identification and assessment of the relevant technology needed to support high-priority research, (2) identify LSRF technology impacts on Space Station systems, and (3) provide a technology development plan that will lead to the design and ultimate development of the LSRF critical technology. The most significant study results that will be reported include: (1) identification of experiment technology and system support requirements, (2) definitions of key equipment needed to support specific experiments and experiment groups, (3) establishment of equipment technology status, (4) definition of pacing equipment areas requiring supporting research and technology (SRT), (5) technology development plans, cost and schedules for identified flight hardware and related SRT, and (6) LSRF/Space Station interfaces and accommodation impacts. Author

A85-34277
THE EUROPEAN VESTIBULAR EXPERIMENTS IN SPACELAB-1
J. KASS, R. VON BAUMGARTEN (Mainz, Universitaet, Mainz, West Germany), A. BENSON (RAF, Institute of Aviation Medicine, Farnborough, Hants., England), A. BERTHOZ (CNRS, Laboratoire de Neurosensorielle, Paris, France), TH. BRANDT, TH. PROBST, H. SCHERER (Klinikum Grosshadern, Munich, West Germany), W. BRUZEK, J. DICHGANS (Neurologische Klinik, Tuebingen, West Germany), U. BRAND et al. (COSPAR, Topical Meeting on Life Sciences and Space Research XXI(1), Graz, Austria, June 25-July 7, 1984) Advances in Space Research (ISSN 0273-1177), vol. 4, no. 10, 1984, p. 3-9. Research supported by the Bundesministerium fuer Forschung und Technologie and Centre National d'Etudes Spatiales. refs

A series of preflight, inflight, and postflight experiments, performed in the Spacelab-1 mission in November-December, 1983 are reported. Various aspects of the functions of the vestibular system, the inflight tests comprising threshold measurements for linear movements in three orthogonal axes, optokinetic stimulation, vestibulo-ocular reflexes under linear and angular accelerations, caloric stimulation with and without linear accelerations and eye counter-rotation measurements are considered by the experiments. The caloric experiment indicates a very significant result: strong caloric nystagmus is observed for the two subjects tested, which is not in agreement with what is expected from Barany's (1907) convection hypothesis for caloric nystagmus. The other experiments show a tendency of the organism after adaptation to weightlessness to ignore the signals from the otolith system and to increase dependence on the visual stimuli. M.D.

A85-34300* California Univ., Berkeley.
NEOPLASTIC CELL TRANSFORMATION BY ENERGETIC HEAVY IONS AND ITS MODIFICATION WITH CHEMICAL AGENTS
T. C. YANG and C. A. TOBIAS (California, University, Berkeley, CA) (COSPAR, Topical Meeting on Life Sciences and Space Research XXI(1), Graz, Austria, June 25-July 7, 1984) Advances in Space Research (ISSN 0273-1177), vol. 4, no. 10, 1984, p. 207-218. NASA-supported research. refs
(Contract NIH-CA-15184; DE-AC03-76SF-00098)

One of the major deleterious late effects of ionizing radiation is related to the induction of neoplasms. In the present report recent experimental results on neoplastic cell transformation by heavy ions are presented, and possible means to circumvent the carcinogenic effect of space radiation are discussed. Biological effects observed in experiments involving the use of energetic heavy ions accelerated at the Bevalac suggest that many of the biological effects observed in earlier space flight experiments may be due to space radiation, particularly cosmic rays. It is found that the effect of radiation on cell transformation is dose-rate dependent. The frequency of neoplastic transformation for a given dose decreases with a decrease of dose rate of Co-60 gamma rays. It is found that various chemical agents give radiation protection, including DMSO. G.R.

A85-36905* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
CURRENT CONCEPTS AND FUTURE DIRECTIONS OF CELSS
R. D. MACELROY (NASA, Ames Research Center, Extraterrestrial Research Div., Moffett Field, CA) and J. BREDT (NASA, Life Sciences Div., Washington, DC) (COSPAR, Workshops on Life Sciences and Space Research XXI/2/, 7th and 11th, Graz, Austria, June 25-July 7, 1984) Advances in Space Research (ISSN 0273-1177), vol. 4, no. 12, 1984, p. 221-229. refs

The components of a bioregenerative life-support system intended for use in space are described and the requirements for system control are discussed. Concepts of such systems include the use of higher plants and/or micro-algae as sources of oxygen, CO2 absorption, potable water, and food. In order to focus on the specific problem of reservoirs and buffers, bioregenerative life support in space is contrasted to terrestrial ecological concepts. Some of the future directions of the NASA CELSS (controlled ecological life-support system) program are outlined. M.D.

A85-36907* Boeing Aerospace Co., Seattle, Wash.
CELSS TRANSPORTATION ANALYSIS
R. L. OLSON, E. A. GUSTAN, and T. J. VINOPAL (Boeing Aerospace Co., Space Systems Div., Seattle, WA) (COSPAR, Workshops on Life Sciences and Space Research XXI/2/, 7th and 11th, Graz, Austria, June 25-July 7, 1984) Advances in Space Research (ISSN 0273-1177), vol. 4, no. 12, 1984, p. 241-250. refs
(Contract NAS2-11148)

The results of a study conducted in order to estimate where potential transportation cost savings can be anticipated by using CELSS technology for selected future manned space missions, are presented. Six manned missions ranging from a low earth orbit mission to those associated with asteroids and a Mars sortie are selected from NASA planning forecasts for study during an analysis of the transportation system. Several environmental control and life-support systems which are used in developing life-support closure scenarios are investigated for estimates of weight, volume, and power requirements. It is shown that when the scenarios are combined with the transportation analysis, mission life-support cost estimates are provided. M.D.

A85-36908
BLSS - A CONTRIBUTION TO FUTURE LIFE SUPPORT
A. I. SKOOG (Dornier System GmbH, Friedrichschafen, West Germany) (COSPAR, Workshops on Life Sciences and Space Research XXI/2/, 7th and 11th, Graz, Austria, June 25-July 7, 1984) Advances in Space Research (ISSN 0273-1177), vol. 4, no. 12, 1984, p. 251-262.

The concepts and requirements for Biological Life Support Systems (BLSS) for extended missions in space are defined, and the feasibility of BLSS is analyzed. In particular, attention is given to the BLSS energy-mass relation and the possibilities to influence it to achieve advantages over physicochemical systems. The major problem areas which need immediate attention are defined; these include microgravity effects, cosmic radiation effects, the use of radiation protection, and monitoring and control (including sensor technology). A program for the development of BLSS is proposed. V.L.

A85-36910
SURVEY OF CELSS CONCEPTS AND PRELIMINARAY RESEARCH IN JAPAN
H. OHYA (Yokohama National University, Yokohama, Japan), T. OSHIMA (Tokyo Institute of Technology, Yokohama, Japan), and K. NITTA (National Aerospace Laboratory, Chofu, Tokyo, Japan) (COSPAR, Workshops on Life Sciences and Space Research XXI/2/, 7th and 11th, Graz, Austria, June 25-July 7, 1984) Advances in Space Research (ISSN 0273-1177), vol. 4, no. 12, 1984, p. 271-277.

Three phases, or missions, and the preliminary proposals and studies needed to establish an operational controlled ecological life support system (CELSS) for a spaceflight are described. Consideration is given to the architecture and to the preliminary design work and system integration for each mission. The experimental and support equipment and systems for the missions are listed in a table. A summary of CELSS-related studies in Japan is presented. M.D.

A85-36911* Life Systems, Inc., Cleveland, Ohio.
ADVANCED REGENERATIVE ENVIRONMENTAL CONTROL AND LIFE SUPPORT SYSTEMS - AIR AND WATER REGENERATION
F. H. SCHUBERT, R. A. WYNVEEN (Life Systems, Inc., Cleveland, OH), and P. D. QUATTRONE (NASA, Ames Research Center, Moffett Field, CA) (COSPAR, Workshops on Life Sciences and Space Research XXI/2/, 7th and 11th, Graz, Austria, June 25-July 7, 1984) Advances in Space Research (ISSN 0273-1177), vol. 4, no. 12, 1984, p. 279-288. Research supported by Life Systems, Inc. and NASA. refs

Extended manned space missions will require regenerative life support techniques. Past U.S. manned missions used nonregenerative expendables, except for a molecular sieve-based carbon dioxide removal system aboard Skylab. The resupply penalties associated with expandables becomes prohibitive as crew size and mission duration increase. The U.S. Space Station, scheduled to be operational in the 1990's, is based on a crew of four to sixteen and a resupply period of 90 days or greater. It will be the first major spacecraft to employ regenerable techniques for life support. The paper uses the requirements for the Space Station to address these techniques. Author

A85-37924
WILL MAN BEAT THE ZERO G BARRIER?
T. FURNISS Flight International (ISSN 0015-3710), vol. 127, June 8, 1985, p. 51-53.

An evaluation is made of U.S. astronaut and Soviet cosmonaut experience to date with the problem of Space Adaptation Syndrome (SAS), in light of requirements for extended weightless activities aboard projected space stations. During space flight, changes in heart and lung function occur which involve a shift of body fluids from the lower to the upper body, diuresis, and a blood volume decrease. Conflicting sensory inputs from vision, the inner ear, etc., cause general confusion as well as motion sickness. The most serious health hazard associated with prolonged weightlessness is the progressive loss of skeletal bone through urinary calcium loss. It has not been possible to reverse the in-flight loss of calcium. O.C.

A85-38269*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
ENVIRONMENTAL CONTROL/LIFE SUPPORT
P. D. QUATTRONE (NASA, Ames Research Center, Moffett Field, CA) IN: Aerospace Testing Seminar, 8th, Los Angeles, CA, March 21-23, 1984, Proceedings . Mount Prospect, IL, Institute of Environmental Sciences, 1984, p. 215-225.

It is pointed out that the life support systems technology used on projects Mercury, Gemini, Apollo, and Space Shuttle required an employment of expendables. Skylab was the only manned space project which made use of regenerable life support technology, taking into account the employment of a silica gel/molecular sieve for carbon dioxide removal. A number of investigations indicate that significant launch weight and volume as well as recurring cost savings can be realized by using regenerative life support processes for a Space Station. A number of developed regenerative processes are believed to be applicable to a Space Station. Aspects of air revitalization are discussed, taking into account carbon dioxide reduction, oxygen generation, trace contaminant control, temperature and humidity control, instrumentation, and nitrogen supply. Attention is also given to water reclamation, solid waste treatment, and future development and testing programs. G.R.

A85-41869
A CONCEPTUAL DESIGN OF A SOLAR-RAY SUPPLY SYSTEM IN THE SPACE STATION
N. TANATSUGU, M. YAMASHITA (Tokyo, University, Japan), and K. MORI (Kieo University, Yokohama, Japan) (University of Tokyo and Ministry of Education, Science, and Culture, Space Energy Symposium, 3rd, Tokyo, Japan, Mar. 26, 1984) Space Solar Power Review (ISSN 0191-9067), vol. 5, no. 2, 1985, p. 221-230.

A solar ray supply system (SRSS) is proposed to meet the sunlight requirements of Space Station agricultural experiments. The system distributes sunlight from a solar ray collector by means of light conducting fiber cable. The following advantages are indentified in comparison with electrical light conversion schemes: (1) the light provided by the SRSS is suitable for photosynthesis in plants because its spectrum is consistent with sunlight on earth; and (2) the SRSS is more efficient (almost 50 percent) due to the direct transmission of solar rays. The spectrum of the solar rays is limited to 350-850 nm in order to avoid possibly harmful exposure by human beings and plants. A modification of the basic system design is recommended to supply solar rays with a wider spectral range for solar pumped lasers and photochemical production facilities. I.H.

N85-23299*# Federation of American Societies for Experimental Biology, Bethesda, Md. Life Sciences Research Office.
RESEARCH OPPORTUNITIES IN HUMAN BEHAVIOR AND PERFORMANCES
J. M. CHRISTENSEN and J. M. TALBOT Washington NASA Apr. 1985 79 p refs
(Contract NASW-3924)
(NASA-CR-3886; NAS 1.26:3886) Avail: NTIS HC A05/MF A01 CSCL 05I

The NASA research program in the biological and medical aspects of space flight includes investigations of human behavior and performance. The research focuses on psychological and psychophysiological responses to operational and environmental stresses and demands of spaceflight, and encompasses problems in perception, cognition, motivation, psychological stability, small group dynamics, and performance. The primary objective is to acquire the knowledge and methodology to aid in achieving high productivity and essential psychological support of space and ground crews in the Space Shuttle and space station programs. The Life Sciences Research Office (LSRO) of the Federation of American Societies for Experimental Biology reviewed its program in psychology and identified its research for future program planning to be in line with NASA's goals. B.G.

N85-24733*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
FOOD SERVICE AND NUTRITION FOR THE SPACE STATION
R. L. SAUER, ed. Apr. 1985 99 p refs Workshop held in Houston, Tex., 10-11 Apr. 1984
(NASA-CP-2370; S-541; NAS 1.55:2370) Avail: NTIS HC A05/MF A01 CSCL 06H

The proceedings of the Workshop on Food Service and Nutrition for the Space Station, held in Houston, Texas, on April 10 and 11, 1984 was given. The workshop was attended by experts in food technology from industry, government, and academia. Following a general definition of unique space flight requirements, oral presentations were made on state of the art food technology with the objective of using this technology to support the space flight requirements. Numerous areas are identified which in the opinion of the conferees, would have space flight application. But additional effort, evaluation, or testing to include Shuttle inflight testing will be required for the technology to be applied to the Space Station.

N85-24734*# Little (Arthur D.), Inc., Cambridge, Mass.
THE CONTEXT FOR FOOD SERVICE AND NUTRITION IN THE SPACE STATION
P. E. GLASER *In* NASA. Lyndon B. Johnson Space Center Food Serv. and Nutr. for the Space Shuttle p 4-11 Apr. 1985 refs
Avail: NTIS HC A05/MF A01 CSCL 06H

Commercial activities in space represent diverse markets where international competitors will be motivated by economic, technical and political considerations. These considerations are given and discussed. The space station program, industrial participation and the potential benefits of commercial activities in space are described. How food service and nutrition affects habitability, effects *on physical condition, dietary goals, food preparation and meal* service are detailed. E.R.

N85-24736*# Hilton (Conrad N.) Coll. of Hotel and Restaurant Management, Houston, Tex.
FOOD SERVICE MANAGEMENT
C. L. RAPPOLE and S. A. LOUVIER (Houston Univ.) *In* NASA. Lyndon B. Johnson Space Center Food Serv. and Nutr. for the Space Shuttle p 16-19 Apr. 1985
Avail: NTIS HC A05/MF A01 CSCL 06H

A study to design a food service system using current technology to serve a small scale Space Station was conducted. The psychological, sociological and nutritional factors affecting feeding in microgravity conditions was investigated. The logistics of the food service system was defined. E.R.

N85-24739*# Little (Arthur D.), Inc., Cambridge, Mass.
ALTERNATIVE FOOD PRESERVATION TECHNIQUES, NEW TECHNOLOGY IN FOOD PREPARATION AND APPROPRIATENESS OF FOOD SUPPLY FOR THE PERMANENTLY MANNED SPACE STATION
R. H. WHELAN *In* NASA. Lyndon B. Johnson Space Center Food Serv. and Nutr. for the Space Shuttle p 30-32 Apr. 1985
Avail: NTIS HC A05/MF A01 CSCL 06H

Alternative food preservation techniques are defined as unique processes and combinations of currently used processes for food preservation. Food preservation is the extension of the useful shelf-life of normally perishable foods (from harvest to final consumption) by controlling micro-organisms, enzymes, chemical changes, changes in sensory characteristics and the prevention of subsequent recontamination. The resulting products must comply with all applicable food manufacturing practice regulations and be safe. Most of the foods currently used in both space and military feeding are stabilized either by dehydration or the use of a terminal sterilization process. Other available options would be formulation to reduce water activity, the refrigeration and freezing of perishable foods, chemical addition, and physical treatment (ionizing or nonionizing radiation or mechanical action). These alternatives are considered and proposals made. Author

N85-24742*# Department of the Army, Washington, D. C.
NUTRITIONAL CRITERIA FOR MILITARY RATIONS AND EFFECTS OF PROLONGED FEEDING ON ACCEPTABILITY
D. SCHNAKENBERG *In* NASA. Lyndon B. Johnson Space Center Food Serv. and Nutr. for the Space Shuttle p 47-48 Apr. 1985
Avail: NTIS HC A05/MF A01 CSCL 06H

Broad nutritional policies for operational rations are designed to insure that the nutritional content of the rations served will sustain combat effectiveness. Concern exists that these rations, although nutritionally complete, would become monotonous because of limited variety causing nutrient intake to decrease and body weight losses to occur with adverse effects on morale and combat effectiveness. Whenever possible, troops are now fed one or two hot meals per day containing fresh foods and a much greater variety of foods than are available in packaged rations. A laboratory test was conducted with student volunteers and the results are discussed. B.G.

N85-24744*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
FOOD SERVICE AND NUTRITIONAL NEEDS
J. KERWIN *In its* Food Serv. and Nutr. for the Space Shuttle p 53-55 Apr. 1985
Avail: NTIS HC A05/MF A01 CSCL 06H

The difficulty is that as we go into the Space Station world, the cost, effort, hardware, food trash, and food waste that the food service system will generate (which is quite tolerable on a 7 day mission), probably will be intolerable on a 90 day Space Station mission. The challenge in the food service supply is not so much packaging but systems engineering. The big constraints are in the supply pipeline. Those constraints and the possible tradeoffs are discussed. B.G.

N85-24746*# Signode Corp., Glenview, Ill. Corporate Planning and Development Dept.
PACKAGING'S CONTRIBUTION FOR THE EFFECTIVENESS OF THE SPACE STATION'S FOOD SERVICE OPERATION
B. A. RAUSCH *In* NASA. Lyndon B. Johnson Space Center Food Serv. and Nutr. for the Space Shuttle p 59-62 Apr. 1985
Avail: NTIS HC A05/MF A01 CSCL 06H

Storage limitations will have a major effect on space station food service. For example: foods with low bulk density such as ice cream, bread, cake, standard type potato chips and other low density snacks, flaked cereals, etc., will exacerbate the problem of space limitations; package containers are inherently volume consuming and refuse creating; and the useful observation that the optimum package is no package at all leads to the tentative conclusion that the least amount of packaging per unit of food, consistent with storage, aesthetics, preservation, cleanliness, cost and disposal criteria, is the most practical food package for the space station. A series of trade offs may have to be made to arrive at the most appropriate package design for a particular type of food taking all the criteria into account. Some of these trade offs are: single serve vs. bulk; conventional oven vs. microwave oven; nonmetallic aseptically vs. non-aseptically packaged foods; and comparison of aseptic vs. nonaseptic food packages. The advantages and disadvantages are discussed. B.G.

N85-24747*# Little (Arthur D.), Inc., Cambridge, Mass.
PACKAGING FOR FOOD SERVICE
E. J. STILWELL *In* NASA. Lyndon B. Johnson Space Center Food Serv. and Nutr. for the Space Shuttle p 63-66 Apr. 1985
Avail: NTIS HC A05/MF A01 CSCL 06H

Most of the key areas of concern in packaging the three principle food forms for the space station were covered. It can be generally concluded that there are no significant voids in packaging materials availability or in current packaging technology. However, it must also be concluded that the process by which packaging decisions are made for the space station feeding program will be very synergistic. Packaging selection will depend heavily on the preparation mechanics, the preferred presentation and the

achievable disposal systems. It will be important that packaging be considered as an integral part of each decision as these systems are developed. B.G.

N85-26604*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
CONTROLLED ECOLOGICAL LIFE SUPPORT SYSTEMS (CELSS)
M. MAJUMDAR *In its* NASA Ames Summer High School Apprenticeship Res. Program p 81-87 Apr. 1985 refs
Avail: NTIS HC A06/MF A01 CSCL 06K

One of the major problems facing researchers in the design of a life support system is to construct it so that it will be capable of regulating waste materials and gases, while at the same time supporting the inhabitants with adequate food and oxygen. The basis of any gaseous life supporting cycle is autotrophs (plants that photosynthesize). The major problem is to get the respiratory quotient (RQ) of the animals to be equivalent to the assimilatory quotient (AQ) of the plants. A technique is being developed to control the gas exchange. The goal is to determine the feasibility of manipulating the plant's AQ by altering the plants environment in order to eliminate the mismatch between the plant's AQ and the animal's RQ. B.G.

N85-27930*# Rockwell International Corp., Downey, Calif. Space Station Systems Div.
SPACE STATION CREW SAFETY ALTERNATIVES STUDY. VOLUME 5: SPACE STATION SAFETY PLAN Final Report
G. H. MEAD, R. L. PEERCY, JR., and R. F. RAASCH Washington NASA Jun. 1985 114 p
(Contract NAS1-17242)
(NASA-CR-3858; NAS 1.26:3858; SSD84-0055) Avail: NTIS HC A06/MF A01 CSCL 22A

The Space Station Safety Plan has been prepared as an adjunct to the subject contract final report, suggesting the tasks and implementation procedures to ensure that threats are addressed and resolution strategy options identified and incorporated into the space station program. The safety program's approach is to realize minimum risk exposure without levying undue design and operational constraints. Safety objectives and risk acceptances are discussed. B.W.

N85-28958*# Rockwell International Corp., Downey, Calif. Space Station Systems Div.
SPACE STATION CREW SAFETY ALTERNATIVES STUDY. VOLUME 4: APPENDICES Final Report
R. L. PEERCY, JR., R. F. RAASCH, and L. A. ROCKOFF Washington NASA Jun. 1985 111 p
(Contract NAS1-17242)
(NASA-CR-3857; NAS 1.26:3857; SSD84-0053-VOL-4) Avail: NTIS HC A06/MF A01 CSCL 22B

The scope of this study considered the first 15 years of accumulated space station concepts for Initial Operational Capability (10C) during the early 1990's. Twenty-five threats to the space station are identified and selected threats addressed as impacting safety criteria, escape and rescue, and human factors safety concerns. Of the 25 threats identified, eight are discussed including strategy options for threat control: fire, biological or toxic contamination, injury/illness, explosion, loss of pressurization, radiation, meteoroid penetration and debris. B.W.

N85-29531*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
CONTROLLED ECOLOGICAL LIFE SUPPORT SYSTEM. LIFE SUPPORT SYSTEMS IN SPACE TRAVEL
R. D. MACELROY, ed., D. T. SMERNOFF, ed. (New Hampshire Univ., Durham), and H. P. KLEIN, ed. (Santa Clara Univ., Calif.) Jun. 1985 74 p refs Proc. of the 25th COSPAR Meeting, held in Graz, Jul. 1984
(NASA-CP-2378; A-85190; NAS 1.55:2378) Avail: NTIS HC A04/MF A01 CSCL 06K

Life support systems in space travel, in closed ecological systems were studied. Topics discussed include: (1) problems of life support and the fundamental concepts of bioregeneration; (2) technology associated with physical/chemical regenerative life support; (3) projection of the break even points for various life support techniques; (4) problems of controlling a bioregenerative life support system; (5) data on the operation of an experimental algal/mouse life support system; (6) industrial concepts of bioregenerative life support; and (7) Japanese concepts of bioregenerative life support and associated biological experiments to be conducted in the space station.

N85-29532*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
CURRENT CONCEPTS AND FUTURE DIRECTIONS OF CELSS
R. D. MACELROY and J. BREDT *In its* Controlled Ecol. Life Support System p 1-9 Jun. 1985 refs
Avail: NTIS HC A04/MF A01 CSCL 06K

Bioregenerative life support systems for use in space were studied. Concepts of such systems include the use of higher plants and/or microalgae as sources of food, potable water and oxygen, and as sinks for carbon dioxide and metabolic wastes. Recycling of materials within the system will require processing of food organism and crew wastes using microbiological and/or physical chemical techniques. The dynamics of material flow within the system will require monitoring, control, stabilization and maintenance imposed by computers. Studies included higher plant and algal physiology, environmental responses, and control; flight experiments for testing responses of organisms to weightlessness and increased radiation levels; and development of ground based facilities for the study of recycling within a bioregenerative life support system. E.A.K.

N85-29533*# Yokohama National Univ. (Japan). Dept. of Chemical Engineering.
SURVEY OF CELSS CONCEPTS AND PRELIMINARY RESEARCH IN JAPAN
H. OHYA, T. OSHIMA (Tokyo Inst. of Tech.), and K. NITTA (National Aerospace Lab., Tokyo, Japan) *In* NASA. Ames Research Center Controlled Ecol. Life Support System p 10-16 Jun. 1985 refs
Avail: NTIS HC A04/MF A01 CSCL 06K

Agricultural and other experiments relating to the development of a controlled ecological life support system (CELSS) were proposed. The engineering feasibility of each proposal was investigated by a CELSS experiment concept met study group. The CELSS experiment concept to clarify the goals of CELSS and to determine three phases to achieve the goals. The resulting phases, or missions, and preliminary proposals and studies needed to develop a CELSS are described. E.A.K.

N85-29534*# Dornier-Werke G.m.b.H., Friedrichshafen (West Germany).
BLSS: A CONTRIBUTION TO FUTURE LIFE SUPPORT
A. I. SKOOG *In* NASA. Ames Resarch Center Controlled Ecol. Life Support System p 17-28 Jun. 1985 refs
Avail: NTIS HC A04/MF A01 CSCL 06K

The problem of the supply of basic life supporting ingredients was analyzed. Storage volume and launch weight of water, oxygen and food in a conventional nonregenerable life support system are directly proportional to the crew size and the length of the mission. Because of spacecraft payload limitations this requires that the carbon, or food, recycling loop, the third and final part in the life support system, be closed to further reduce logistics cost. Advanced life support systems need to be developed in which metabolic waste products are regenerated and food is produced. Biological life support systems (BLSS) satisfy the space station environmental control functions and close the food cycle. Numerous scientific space experiments were delineated, the results of which are applicable to the support of BLSS concepts. Requirements and concepts are defined and the feasibility of BLSS for space application are analyzed. The BLSS energy mass relation, and the possibilities to influence it to achieve advantages for the BLSS are determined. A program for the development of BLSS is proposed. E.A.K.

N85-29535*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
ADVANCED REGENERATIVE ENVIRONMENTAL CONTROL AND LIFE SUPPORT SYSTEMS: AIR AND WATER REGENERATION
F. H. SCHUBERT (Life Systems, Inc., Cleveland, Ohio), R. A. WYNVEEN, and P. D. QUATTRONE (Life Systems, Inc., Cleveland, Ohio) *In its* Controlled Ecol. Life Support System p 29-38 Jun. 1985 refs
Avail: NTIS HC A04/MF A01 CSCL 06K

Extended manned space missions will require regenerative life support techniques. Past manned missions used nonregenerative expendables, except for a molecular sieve based carbon dioxide removal system aboard Skylab. The resupply penalties associated with expendables becomes prohibitive as crew size and mission duration increase. The Space Station scheduled to be operational in the 1990's is based on a crew of four to sixteen and a resupply period of 90 days or greater. It will be the first major spacecraft to employ regenerable techniques for life support. The techniques to be used in the requirements for the space station are addressed. E.A.K.

N85-29536*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
ATMOSPHERE BEHAVIOR IN GAS-CLOSED MOUSE-ALGAL SYSTEMS: AN EXPERIMENTAL AND MODELLING STUDY
M. M. AVERNER, B. MOORE, III (New Hampshire Univ.), I. BARTHOLOMEW (New Hampshire Univ.), and R. WHARTON *In its* Controlled Ecol. Life Support System p 39-46 Jun. 1985 refs
Avail: NTIS HC A04/MF A01 CSCL 06K

A dual approach of mathematical modelling and laboratory experimentation aimed at examining the gas exchange characteristics of artificial animal/plant systems closed to the ambient atmosphere was initiated. The development of control techniques and management strategies for maintaining the atmospheric levels of carbon dioxide and oxygen at physiological levels is examined. A mathematical model simulating the atmospheric behavior in these systems was developed and an experimental gas closed system was constructed. These systems are described and preliminary results are presented. E.A.K.

N85-29538*# Boeing Aerospace Co., Seattle, Wash. Space Systems Div.
CELSS TRANSPORTATION ANALYSIS
R. L. OLSON, E. A. GUSTAN, and T. J. VINOPAL *In* NASA. Ames Research Center Controlled Ecol. Life Support System p 55-64 Jun. 1985 refs
Avail: NTIS HC A04/MF A01 CSCL 06K

Regenerative life support systems based on the use of biological material was considered for inclusion in manned spacecraft. Biological life support systems are developed in the controlled ecological life support system (CELSS) program. Because of the progress achieved in the CELSS program, it is determined which space missions may profit from use of the developing technology. Potential transportation cost savings by using CELSS technology for selected future manned space missions was evaluated. Six representative missions were selected which ranged from a low Earth orbit mission to those associated with asteroids and a Mars sortie. The crew sizes considered varied from four persons to five thousand. Other study parameters included mission duration and life support closure percentages, with the latter ranging from complete resupply of consumable life support materials to 97% closure of the life support system. The analytical study approach and the missions and systems considered, together with the benefits derived from CELSS when applicable are described. E.A.K.

N85-29539*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
PROCEEDINGS OF THE SEMINAR ON SPACE STATION HUMAN PRODUCTIVITY
M. M. COHEN, comp. and E. ROSENBERG, comp. (San Jose State Univ.) Mar. 1985 747 p refs Seminar held at Moffett Field, Calif., 27 Feb. - 2 Mar. 1984
(NASA-TM-86673; NAS 1.15:86673) Avail: NTIS HC A99/MF E03 CSCL 05H

An exploration of the issues which surround some of the elements of the Human Productivity Program is given. Five general topics were discussed: (1) crew safety, (2) internal contamination, (3) the definition of the Human Productivity Program, (4) aspects of architecture that affect productivity, and (5) the role of mock-ups in the Human Productivity Program.

N85-29540*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
SPACE STATION CREW SAFETY: HUMAN FACTORS INTERACTION MODEL
M. M. COHEN and M. K. JUNGE *In its* Proc. of the Seminar on Space Station Human Productivity 11 p Mar. 1985
Avail: NTIS HC A99/MF E03 CSCL 05H

A model of the various human factors issues and interactions that might affect crew safety is developed. The first step addressed systematically the central question: How is this space station different from all other spacecraft? A wide range of possible issue was identified and researched. Five major topics of human factors issues that interacted with crew safety resulted: Protocols, Critical Habitability, Work Related Issues, Crew Incapacitation and Personal Choice. Second, an interaction model was developed that would show some degree of cause and effect between objective environmental or operational conditions and the creation of potential safety hazards. The intermediary steps between these two extremes of causality were the effects on human performance and the results of degraded performance. The model contains three milestones: stressor, human performance (degraded) and safety hazard threshold. Between these milestones are two countermeasure intervention points. The first opportunity for intervention is the countermeasure against stress. If this countermeasure fails, performance degrades. The second opportunity for intervention is the countermeasure against error. If this second countermeasure fails, the threshold of a potential safety hazard may be crossed. R.J.F.

N85-29542*# National Aeronautics and Space Administration. John F. Kennedy Space Center, Cocoa Beach, Fla.
STATEMENT OF CONTAMINATION PROBLEM
W. HOFFLER *In* NASA. Ames Research Center Proc. of the Seminar on Space Station Human Productivity 10 p Mar. 1985
Avail: NTIS HC A99/MF E03 CSCL 06T

Space station contamination information is given. There are five major areas in which there are task requirements: (1) potential contaminants need to be identified, i.e., both the sources and types of contaminants, (2) the scope and magnitude of contaminant effects need to be determined, i.e., toxicological effects, microbacteriological effects and impurities, (3) mathematical models for predictive methods need to be developed. (4) state-of-the-art and advanced technologies for monitoring contaminants and for methods of decontamination need to be identified, and (5) automated monitoring and control systems need to be designed. R.J.F.

N85-29543*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
INTERNAL CONTAMINATION ISSUES
L. A. ROCKOFF *In its* Proc. of the Seminar on Space Station Human Productivity 16 p Mar. 1985
Avail: NTIS HC A99/MF E03 CSCL 06T

Issues concerning contaminated spacecraft atmospheres are identified. Contaminants found in the space shuttle orbiter atmospheric samples are listed. Crew physiological reactions are noted. R.J.F.

N85-29545*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
VENTILATION FLOW: SUBMERGED
D. HUTCHINSON *In its* Proc. of the Seminar on Space Station Human Productivity 30 p Mar. 1985 refs
Avail: NTIS HC A99/MF E03 CSCL 06T

The ventilation system on a submarine is discussed. When the submarine is submerged. The ventilation system provides a conditioned atmosphere in the ship with complete isolation from the outside. A conditioned atmosphere includes not only filtration and temperature and humidity control, but also air purification (removal of potentially harmful quantities of impurities and comtaminants) and revitalization (addition of vital life support oxygen). Carbon dioxide removal, the oxygen system, air conditioning, carbon monoxide removal, hydrogen removal, and atmosphere monitoring systems are among the topics discussed. R.J.F.

N85-29546*# *National Aeronautics and Space Administration.* Ames Research Center, Moffett Field, Calif.
AMBIENT AIR CONTAMINATION: CHARACTERIZATION AND DETECTION TECHNIQUES
C. P. NULTON and H. S. SILVUS *In its* Proc. of the Seminar on Space Station Human Productivity 9 p Mar. 1985 refs
Avail: NTIS HC A99/MF E03 CSCL 06T

Techniques to characterize and detect sources of ambient air contamination are described. Chemical techniques to identify indoor contaminants are outlined, they include gas chromatography, or colorimetric detection. Organics generated from indoor materials at ambient conditions and upon combustion are characterized. Piezoelectric quartz crystals are used as precision frequency determining elements in electronic oscillators. E.A.K.

N85-29547*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
EXTENDED MISSION LIFE SUPPORT SYSTEMS
P. D. QUATTRONE *In its* Proc. of the Seminar on Space Station Human Productivity 19 p Mar. 1985 refs
Avail: NTIS HC A99/MF E03 CSCL 06K

Extended manned space missions which include interplanetary missions require regenerative life support systems. Manned mission life support considerations are placed in perspective and previous manned space life support system technology, activities and accomplishments in current supporting research and technology (SR&T) programs are reviewed. The life support subsystem/system technologies required for an enhanced duration orbiter (EDO) and a space operations center (SOC), regenerative life support functions and technology required for manned interplanetary flight vehicles, and future development requirements are outlined. The Space Shuttle Orbiters (space transportation system) is space cabin atmosphere is maintained at Earth ambient pressure of 14.7 psia (20% O2 and 80% N2). The early Shuttle flights will be seven-day flights, and the life support system flight hardware will still utilize expendables. E.A.K.

N85-29548*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
SPACE SHUTTLE REVITALIZATION SYSTEM
P. D. QUATTRONE *In its* Proc. of the Seminar on Space Station Human Productivity 30 p Mar. 1985
Avail: NTIS HC A99/MF E03 CSCL 06K

The Space Shuttle air revitalization system is discussed. The sequential steps in loop closure are examined and a schematic outline of the regenerative air revitalization system is presented. Carbon dioxide reduction subsystem concepts are compared. Schemes are drawn for: static feedwater electrolysis cell, solid polymer electrolyte water electrolysis cell, air revitalization system, nitrogen generation reactions, nitrogen subsystem staging, vapor compression distillation subsystem, thermoelectric integrated membrane evaporation subsystem, catalytic distillation water reclamation subsystem, and space shuttle solid waste management system. DOE

N85-29549*# Hamilton Standard, Hartford, Conn.
INTERNAL CONTAMINATION IN THE SPACE STATION
C. POYTHRESS *In* NASA. Ames Research Center Proc. of the Seminar on Space Station Human Productivity 25 p Mar. 1985 refs
Avail: NTIS HC A99/MF E03 CSCL 06T

Atmosphere trace contaminant control systems used in the past (Lunar Module and Skylab) and present (nuclear submarines and Shuttle) are discussed. Recommendations are made for the future Space Station contaminant control system. The prevention and control methods used are judicious material selection, detection, and specific removal equipment. Sources and effects of contamination relating to crew and equipment are also discussed. E.A.K.

N85-29550*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
SPACE STATION TRACE CONTAMINANT CONTROL
T. OLCUTT *In its* Proc. of the Seminar on Space Station Human Productivity 16 p Mar. 1985
Avail: NTIS HC A99/MF E03 CSCL 06T

Different systems for the control of space station trace contaminants are outlined. The issues discussed include: spacecabin contaminant sources, technology base, contaminant control system elements and configuration, approach to contaminant control, contaminant load model definition, spacecraft maximum allowable concentrations, charcoal bed sizing and performance characteristics, catalytic oxidizer sizing and performance characteristics, special sorbent bed sizing, animal and plant research payload problems, and emergency upset contaminant removal. It is concluded that the trace contaminant control technology base is firm, the necessary hardware tools are available, and the previous design philosophy is still applicable. Some concerns are the need as opposed to danger of the catalytic oxidizer, contaminants with very low allowable concentrations, and the impact of relaxing materials requirements. E.A.K.

N85-29551*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
GAS CHROMATOGRAPHY: POSSIBLE APPLICATION OF ADVANCED INSTRUMENTATION DEVELOPED FOR SOLAR SYSTEM EXPLORATION TO SPACE STATION CABIN ATMOSPHERES
G. C. CARLE *In its* Proc. of the Seminar on Space Station Human Productivity 15 p Mar. 1985
Avail: NTIS HC A99/MF E03 CSCL 06T

Gas chromatography (GC) technology was developed for flight experiments in solar system exploration. The GC is a powerful analytical technique with simple devices separating individual components from complex mixtures to make very sensitive quantitative and qualitative measurements. It monitors samples containing mixtures of fixed gases and volatile organic molecules. The GC was used on the Viking mission in support of life detection experiments and on the Pioneer Venus Large Probe to determine the composition of the venusian atmosphere. A flight GC is under development to study the progress and extent of STS astronaut denitrogenation prior to extravehicular activity. Advanced flight GC concepts and systems for future solar system exploration are also studied. Studies include miniature ionization detectors and associated control systems capable of detecting from ppb up to 100% concentration levels. Further miniaturization is investigated using photolithography and controlled chemical etching in silicon wafers. Novel concepts such as ion mobility drift spectroscopy and multiplex gas chromatography are also developed for future flight experiments. These powerful analytical concepts and associated hardware are ideal for the monitoring of cabin atmospheres containing potentially dangerous volatile compounds. E.A.K.

N85-29552*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
MASS SPECTROMETRY TECHNOLOGY AT THE JET PROPULSION LABORATORY (JPL)
C. E. GIFFIN *In* NASA. Ames Research Center Proc. of the Seminar on Space Station Human Productivity 17 p Mar. 1985
Avail: NTIS HC A99/MF E03 CSCL 06T

Recent developments in the field of mass spectrometry taking place at the Caltech Jet Propulsion Laboratory are highlighted. The pertinent research and development is aimed at producing an ultrahigh sensitivity mass spectrograph for both spaceflight and terrestrial applications. The unique aspect of the JPL developed technology is an integrating focal plane ion detector that obviates the need for spectral scanning since all ions over a wide mass range are monitored simultaneously. The ion detector utilizes electro-optical technology and is therefore referred to as an Electro-Optical Ion Detector (EOID). A technical description of the JPL MS/EOID, some of the current applications, and its potential benefits for internal contamination analysis are discussed. B.W.

N85-29554*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
SOME PROBLEMS ASSOCIATED WITH TRACE CONTAMINANT REMOVAL SYSTEMS FOR SPACECABINS
T. WYDEVEN *In its* Proc. of the Seminar on Space Station Human Productivity 15 p Mar. 1985
Avail: NTIS HC A99/MF E03 CSCL 06T

Potential problems associated with acid gas sorbents, activated charcoal beds and the catalytic oxidizer proposed for spacecabin trace contaminant control are discussed. The need for further research on atmospheric trace contaminant control methods is noted. B.W.

N85-29555*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
CONTAMINATION CONTROL FOR INCREASED CREW PRODUCTIVITY
D. B. HEPPNER and C. W. MILLER *In its* Proc. of the Seminar on Space Station Human Productivity 29 p Mar. 1985
Avail: NTIS HC A99/MF E03 CSCL 06T

Contamination control methods that contribute to increased spacecrew productivity are examined in detail. Space station contaminant sources in the water and in the air are described. B.W.

N85-29556*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
HUMAN PRODUCTIVITY PROGRAM DEFINITION
D. B. CRAMER *In its* Proc. of the Seminar on Space Station Human Productivity 26 p Mar. 1985
Avail: NTIS HC A99/MF E03 CSCL 06K

The optimization of human productivity on the space station within the existing resources and operational constraints is the aim of the Human Productivity Program. The conceptual objectives of the program are as follows: (1) to identify long lead technology; (2) to identify responsibility for work elements; (3) to coordinate the development of crew facilities and activities; and (4) to lay the foundation for a cost effective approach to improving human productivity. Human productivity work elements are also described and examples are presented. B.W.

N85-29557*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
THE HUMAN ROLE IN SPACE (THURIS)
H. L. WOLBERS *In its* Proc. of the Seminar on Space Station Human Productivity 42 p Mar. 1985
Avail: NTIS HC A99/MF E03 CSCL 06K

An overview of the human role in space station activities is presented. Associated factors such as performance cost, and risk are discussed. Benefits gained from previous successful manned space missions are highlighted. Human qualifications and capabilities associated with man machine systems are explored. Candidate procedures to be carried out by extravehicular activity spacecrews are described. B.W.

N85-29558*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
OVERVIEW: HUMAN FACTORS ISSUES IN SPACE STATION ARCHITECTURE
M. M. COHEN *In its* Proc. of the Seminar on Space Station Human Productivity 27 p Mar. 1985
Avail: NTIS HC A99/MF E03 CSCL 06K

An overview is presented of human factors issues in space station architecture. The status of the space station program is given. Habitability concerns such as vibroacoustics, lighting systems, privacy and work stations are discussed in detail. B.W.

N85-29559*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
A PRELIMINARY HUMAN FACTORS PLANNING AND DESIGN OUTLINE OF PARAMETERS RELATED TO SPACE STATION WINDOWS AND CCTV MONITORING
R. F. HAINES *In its* Proc. of the Seminar on Space Station Human Productivity 12 p Mar. 1985
Avail: NTIS HC A99/MF E03 CSCL 06K

The question of the merits of placing windows on proposed future space stations is addressed. The use of windows for human visual capabilities is compared to using closed circuit television. Placement and field of view, as well as the number of windows is discussed. G.L.C.

N85-29560*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
HUMAN FACTORS ISSUES IN SPACE STATION ARCHITECTURE
J. LEWIS *In* NASA. Ames Research Center Proc. of the Seminar on Space Station Human Productivity 13 p Mar. 1985
Avail: NTIS HC A99/MF E03 CSCL 05H

Space station human productivity is considered from the prospective of human factors engineering in space station architecture. G.L.C.

N85-29562*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
SOME IDEAS AND QUESTIONS REGARDING SPACE STATION DESIGN FOR HUMAN USE
S. SKOLNICK *In its* Proc. of the Seminar on Space Station Human Productivity 9 p Mar. 1985
Avail: NTIS HC A99/MF E03 CSCL 05H

Design concepts for interior utility of space station crew areas are offered. Planning of a living environment that maintains elements of humanity is stressed. G.L.C.

N85-29563*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
HUMAN PRODUCTIVITY EXPERIENCE AND UNDERSEA HABITAT DESIGN
T. C. TAYLOR (TAI) and J. S. SPENCER (SHDA) *In its* Proc. of the Seminar on Space Station Human Productivity 16 p Mar. 1985
Avail: NTIS HC A99/MF E03 CSCL 05H

Lessons learned from the Alaskan North Slope construction camps and the Western Regional Undersea Laboratory are analyzed with respect to possible improvements for space station interior space utilization and living areas. The human factors engineering aspects have a direct bearing on the condition of crew and occupants. G.L.C.

N85-29564*# Boeing Co., Seattle, Wash.
CONSIDERATIONS FOR SPACE STATION INTERIOR ARCHITECTURE
B. GRIFFIN *In* NASA. Ames Research Center Proc. of the Seminar on Space Station Human Productivity 63 p Mar. 1985
Avail: NTIS HC A99/MF E03 CSCL 05H

Human factors were taken into consideration as a major design

factor for space station design. Other considerations include occupant activity and interior architecture. G.L.C.

N85-29565*# Hamilton Standard, Hartford, Conn.
HUMAN FACTORS IN SPACE STATION ARCHITECTURE: THE ECLSS MODULE CONCEPT
C. POYTHRESS *In* NASA. Ames Research Center Proc. of the Seminar on Space Station Human Productivity 14 p Mar. 1985
Avail: NTIS HC A99/MF E03 CSCL 05H

Human factors engineering concepts were considered for the ECLSS module concept space station. ECLS modules were conceptually examined to determine their advantages and disadvantages. G.L.C.

N85-29566*# Lockheed Aircraft Corp., Burbank, Calif.
HABITABILITY SLEEP ACCOMMODATIONS
H. T. FISHER *In* NASA. Ames Research Center Proc. of the *Seminar on Space Station Human Productivity* 14 p Mar. 1985
Avail: NTIS HC A99/MF E03 CSCL 05H

Schematic outlines are presented with various design requirements for the accommodation of the spacecrew of Space Stations. The primary concern is for sleeping accommodations. Some other general requirements given are for a rest place, entertainment, dressing area, personal item stowage, body restraint, total privacy, external viewing, and grooming provisions. Several plans are given for sleep quarters concepts. E.R.

N85-29568*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
SIMULATION FOR HUMAN FACTORS RESEARCH. A CENTRAL QUESTION: FIDELITY
D. NAGEL *In its* Proc. of the Seminar on Space Station Human Productivity 4 p Mar. 1985
Avail: NTIS HC A99/MF E03 CSCL 05H

Generalized outlines are presented for simulation in human factors research. Recent trends in aeronautical simulation are given. Some criteria for effective training devices are also given. Full system/full mission simulation in aviation and in space human factors research is presented. E.R.

N85-29569*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
SPACE STATION MODELS, MOCKUPS AND SIMULATORS
K. H. MILLER and A. OSGOOD *In its* Proc. of the Seminar on Space Station Human Productivity 8 p Mar. 1985
Avail: NTIS HC A99/MF E03 CSCL 05H

Schematic outlines for space station models, mockups, and simulators are presented. The types of Boeing models, mockups, and simulators are given along with the classes and characteristics. The use of models in the 767 program is briefly given. Computerized human factors tools are outlined. The use of computer aided design and computer aided manufacturing in the approach for the space station is advocated. E.R.

N85-29570*# Lockheed Aircraft Corp., Burbank, Calif.
MOCKUPS AND HUMAN PRODUCTIVITY STUDIES
T. FISHER *In* NASA. Ames Research Center Proc. of the Seminar on Space Station Human Productivity 20 p Mar. 1985
Avail: NTIS HC A99/MF E03 CSCL 05H

Idea outlines are presented concerning mockup candidates, mockup utilization and schedules/sequence in mockup development. Mockup candidates which aid in human productivity investigations and assessment are given. Areas which are considered in the mockups are the safe haven zone, general purpose workstations, maintenance and servicing area, sleep quaters, multiple docking adapter, airlock, hygiene station, food station, habitation zones, group gathering area and lab areas. Some aesthetic concerns in human productivity are also given. E.R.

N85-29572*# Rockwell International Corp., Pittsburgh, Pa. Crew/Habitation Group.
ROCKWELL EXPERIENCE APPLICATIONS TO AMES SPACE STATION MOCKUP HABITABILITY/PRODUCTIVITY STUDIES
J. A. ROEBUCK *In* NASA. Ames Research Center Proc. of the Seminar on Space Station Human Productivity 17 p Mar. 1985
Avail: NTIS HC A99/MF E03 CSCL 05H

The use of Rockwell experiences to assist NASA/Ames with planning for space station mockup studies is outlined. Mockup lessons from Rockwell spacecraft studies are reviewed. Typical and unique mockup technology applications are illustrated. Potential uses for space station mockups are given along with the areas of concern. Workstation design requirements are given. E.R.

N85-29984*# Rockwell International Corp., Downey, Calif. Space Station Systems Div.
SPACE STATION CREW SAFETY ALTERNATIVES STUDY. VOLUME 3: SAFETY IMPACT OF HUMAN FACTORS Final Report
L. A. ROCKOFF, R. F. RAASCH, and R. L. PEERCY, JR. Washington NASA Jun. 1985 68 p
(Contract NAS1-17242)
(NASA-CR-3856; NAS 1.26:3856; SSD84-0053-VOL-3) Avail: NTIS HC A04/MF A01 CSCL 22B

The first 15 years of accumulated space station concepts for Initial Operational Capability (IOC) during the early 1990's was considered. Twenty-five threats to the space station are identified and selected threats addressed as impacting safety criteria, escape and rescue, and human factors safety concerns. Of the 25 threats identified, eight are discussed including strategy options for threat control: fire, biological or toxic contamination, injury/illness, explosion, loss of pressurization, radiation, meteoroid penetration and debris. Of particular interest here is volume three (of five volumes) pertaining to the safety impact of human factors.
Author

N85-29985*# Rockwell International Corp., Downey, Calif. Space Station Systems Div.
SPACE STATION CREW SAFETY ALTERNATIVES STUDY, VOLUME 1 Final Summary Report
R. L. PEERCY, JR., R. F. RAASCH, and L. A. ROCKOFF Washington NASA Jun. 1985 145 p 5 Vol.
(Contract NAS1-17242)
(NASA-CR-3854; NAS 1.26:3854; SSD84-0053) Avail: NTIS HC A07/MF A01 CSCL 22B

The first 15 years of accumulated space station concepts for initial operational capability (IOC) during the early 1990's were considered. Twenty-five threats to the space station are identified and selected threats addressed as impacting safety criteria, escape and rescue, and human factors safety concerns. Of the 25 threats identified, eight are discussed including strategy options for threat control: fire, biological or toxic contamination, injury/illness, explosion, loss of pressurization, radiation, meteoroid penetration and debris. E.A.K.

N85-30625# Los Alamos Scientific Lab., N. Mex. Experimental Pathology Group.
FLOW CYTOMETRY FOR HEALTH MONITORING IN SPACE
J. H. JETT, J. C. MARTIN, C. C. SAUNDERS, and C. C. STEWART 1984 26 p refs Presented at the Lunar Bases and Space Activities of the 21st Century Conf., Washington, D.C., Oct. 1984
(Contract W-7405-ENG-36)
(DE85-009572; LA-UR-85-802; CONF-8410230-11) Avail: NTIS HC A03/MF A01

Monitoring the health of space station or lunar base residents will be necessary to provide knowledge of the physiological status of astronauts. Flow cytometric techniques are uniquely capable of providing cellular, chromosome, hormone level and enzyme level information. The use of dye provides the basis for fluorescently labeling specific cellular components. Laser induced fluorescence from stained cells is quantitated in a flow cytometer to measure cellular components such as DNA, RNA and protein. One major

application of a flow cytometer is to perform a complete blood count including hematocrit, hemoglobin content, and numbers of platelets, erythrocytes, granulocytes, lymphocytes and monocytes. A newly developed flow cytometry based fluoroimmunoassay measures levels of serum enzymes and hormones. It also quantitates radiation exposure and some forms of chromosome damage with flow cytometric measurements. DOE

N85-31811# Massachusetts Inst. of Tech., Cambridge. Man-Vehicle Lab.
SPATIAL ORIENTATION IN WEIGHTLESSNESS AND READAPTATION TO EARTH'S GRAVITY
L. R. YOUNG, WATT. D. G. (McGill Univ.), C. M. OMAN, K. E. MONEY (Defence and Civil Inst. of Environmental Medicine), and B. K. LICHTENBERG *In* AGARD Results of Space Expt. in Physiol. and Med. and Informal Briefings by the F-16 Med. Working Group 6 p Mar. 1985 refs
Avail: NTIS HC A08/MF A01

Unusual vestibular responses to head movements in weightlessness may produce spatial orientation illusions and symptoms of space motion sickness. An integrated set of experiments was performed during Spacelab 1, as well as pre and postflight, to evaluate otolith organ and semicircular canal mediated responses by a variety of measurements, including eye movements, postural control, perception of orientation and motion sickness susceptibility. Author

N85-31821# Deutsche Versuchsanstalt fuer Luft- und Raumfahrt, Cologne (West Germany). Inst. for Aerospace Medicine.
BIOSTACK EXPERIMENTS ON STS-FLIGHTS AND THE IMPACT FOR MAN IN SPACE
H. BUECKER *In* AGARD Results of Space Expt. in Physiol. and Med. and Informal Briefings by the F-16 Med. Working Group 8 p Mar. 1985 refs
Avail: NTIS HC A08/MF A01

The radiobiological properties of the heavy ions of cosmic radiation were investigated on Spacelab 1 by use of biostacks, monolayers of biological test organisms sandwiched between thin foils of different types of nuclear track detectors. Biostacks were exposed to cosmic radiation at several locations with different shielding environments in the module and on the pallet. Evaluations of the physical and biological components of the experiment to data indicate that in general they survived the spaceflight in good condition. Dosimetric data are presented for the different shielding environments. Author

N85-32133*# Rockwell International Corp., Downey, Calif. Space Station Systems Div.
SPACE STATION CREW SAFETY ALTERNATIVES STUDY. VOLUME 2: THREAT DEVELOPMENT Final Report
R. F. RAASCH, R. L. PEERCY, JR., and L. A. ROCKOFF Washington NASA Jun. 1985 239 p 5 Vol.
(Contract NAS1-17242)
(NASA-CR-3855; NAS 1.26:3855; SSD84-0053) Avail: NTIS HC A11/MF A01 CSCL 22B

The first 15 years of accumulated space station concepts for initial operational capability (IOC) during the early 1990's were considered. Twenty-five threats to the space station are identified and selected threats addressed as impacting safety criteria, escape and rescue, and human factors safety concerns. Of the 25 threats identified, eight are discussed including strategy options for threat control: fire, biological or toxic contamination, injury/illness, explosion, loss of pressurization, radiation, meteoroid penetration, and debris. E.A.K.

N85-32772*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
LIVING ALOFT: HUMAN REQUIREMENTS FOR EXTENDED SPACEFLIGHT
M. M. CONNORS, A. A. HARRISON (California Univ., Davis), and F. R. AKINS (Santa Clara Univ., Calif.) Washington 1985 426 p refs Original contains color illustrations
(NASA-SP-483; NAS 1.21:483) Avail: NTIS HC A19/MF A01; SOD HC $14.00 as 033-000-00949-6 CSCL 06K

Human psychological and social adjustment to space is investigated. Studies and experiences bearing on human performance capability, psychological well being, and social organization, as they relate to space, were identified and assessed, and suggestions offered as to where further research could ease the Earth/space transition. Special emphasis was given to the variables of crew size, crew diversity, and mission duration, all of which can be expected to increase in future spaceflight. By providing a conceptual framework in which issues and related information can be integrated, the hope is to aid in discovering those conditions under which future space travelers can flourish. Author

N85-32796*# McDonnell-Douglas Technical Services Co., Inc., Huntsville, Ala.
SPACE STATION ECLSS INTEGRATION ANALYSIS: SIMPLIFIED GENERAL CLUSTER SYSTEMS MODEL, ECLS SYSTEM ASSESSMENT PROGRAM ENHANCEMENTS
R. E. FERGUSON Aug. 1985 92 p refs
(Contract NAS8-36407)
(NASA-CR-176089; NAS 1.26:176089; MDC-W5040) Avail: NTIS HC A05/MF A01 CSCL 09B

The data base verification of the ECLS Systems Assessment Program (ESAP) was documented and changes made to enhance the flexibility of the water recovery subsystem simulations are given. All changes which were made to the data base values are described and the software enhancements performed. The refined model documented herein constitutes the submittal of the General Cluster Systems Model. A source listing of the current version of ESAP is provided in Appendix A. Author

N85-33682# Joint Publications Research Service, Arlington, Va.
RESULTS OF MICROBIOLOGICAL STUDIES CONDUCTED DURING OPERATION OF SALYUT-6 ORBITAL STATION
S. N. ZALOGUYEV, A. N. VIKTOROV, V. M. SHILOV, V. P. GORSHKOV, K. V. ZARUBINA, M. M. SHINKAREVA, and T. Y. NORKINA *In its* USSR Rept.: Space Biol. and Aerospace Med., Vol. 19, No. 2, Mar. - Apr. 1985 (JPRS-USB-85-004) p 91-94 12 Aug. 1985 refs Transl. into ENGLISH from Kosmich. Biol. i Aviakosmich. Med. (Moscow), v. 19, no. 2, Mar. - Apr. 1985 p 64-66
Avail: NTIS HC A07

The results of microbiological examinations of the Salyut 6 crewmembers and environment are presented. There were few cases of adverse changes in the automicroflora composition, i.e., propagation of staphylococci of a certain biotype among crewmembers. However, no over manifestations of infectious pathology were seen. This allows the conclusion that personal hygiene measures and general hygiene and antiepidemic measures taken before and during Salyut 6 missions were adequate and efficient. Author

06

DYNAMICS AND CONTROLS

Includes descriptions of analytical techniques and computer codes, trade studies, requirements and descriptions of orbit maintenance systems, rigid and flexible body attitude sensing systems and controls such as momentum wheels and/or propulsive schemes.

A85-30263#
SIMPLIFIED LATTICE BEAM FINITE ELEMENTS FOR NONLINEAR STATIC, DYNAMIC, AND POSTBUCKLING ANALYSIS
D. T. BERRY and T. Y. YANG (Purdue University, West Lafayette, IN) IN: Structures, Structural Dynamics, and Materials Conference, 26th, Orlando, FL, April 15-17, 1985, Technical Papers. Part 1 . New York, American Institute of Aeronautics and Astronautics, 1985, p. 316-324. refs
(Contract AF-AFOSR-83-0104)
(AIAA PAPER 85-0694)

The present simple beam finite element, for the modeling of nonlinear geometric behavior in flexible space structure lattice beams having repetitive geometry, is formulated by means of expressions for the strain and kinetic energies of an equivalent beam continuum. Nonlinear effects are accounted for by the use of the incremental stiffness matrix of the equivalent continuum. In order to assess the accuracy and applicability of this nonlinear formulation, solutions are obtained for a series of five linear and nonlinear beam problems having various boundary conditions and applied loads. These solutions are compared to alternative solutions employing a detailed model in which each lattice member is modeled by a single truss bar element. It is found that the present formulation may be used as an efficient substitute for a detailed truss model in static and dynamic analyses of beam-like lattice structures. O.C.

A85-30323#
CONTROL OF DYNAMIC RESPONSE OF A CONTINUUM MODEL OF A LARGE SPACE STRUCTURE
S. N. ATLURI (Georgia Institute of Technology, Atlanta, GA) and P. E. ODONOGHUE IN: Structures, Structural Dynamics, and Materials Conference, 26th, Orlando, FL, April 15-17, 1985, Technical Papers. Part 2 . New York, American Institute of Aeronautics and Astronautics, 1985, p. 31-42. refs
(AIAA PAPER 85-0591)

An investigation is conducted into the active control of transient dynamic response in large space structures that are modeled as equivalent continua, with emphasis on the effects of initial stresses on the controllability of transverse dynamic response. A singular solution approach is used to derive a fully coupled set of nodal equations of motion which include nonproportional passive damping, and optimal control techniques are used to develop a feedback control law. Algorithms for the efficient solution of the Riccati equation are implemented, and examples are presented which involve the suppression of structure transient dynamic response vibration by means of an arbitrary number of control force actuators. O.C.

A85-30324#
DYNAMIC ANALYSIS OF A DEPLOYABLE SPACE STRUCTURE
G. E. WEEKS (Alabama, University, Tuscaloosa, AL) IN: Structures, Structural Dynamics, and Materials Conference, 26th, Orlando, FL, April 15-17, 1985, Technical Papers. Part 2 . New York, American Institute of Aeronautics and Astronautics, 1985, p. 43-49. refs
(AIAA PAPER 85-0593)

A mathematical model and simulation code are developed for investigation of the free vibration and forced response behavior of NASA's Solar Array Flight Experiment configuration, modeling the mast as an Euler beam column and the array as a membrane. The resulting partial differential equations of motion are transformed so that boundary conditions are rendered time-invariant, and the subsequent use of the Galerkin method results in an infinite set of second-order differential equations that are truncated and solved for the frequency and forced response behavior of the coupled structural components. Accurate results for frequency and mode shape characteristics are obtainable with only a small number of generalized coordinates. The truncated set of equations was numerically integrated to obtain response histories for pertinent variables from a packaged structure, through full deployment, to complete retraction. O.C.

A85-30334#
USE OF PIEZO-CERAMICS AS DISTRIBUTED ACTUATORS IN LARGE SPACE STRUCTURES
E. F. CRAWLEY and J. DE LUIS (MIT, Cambridge, MA) IN: Structures, Structural Dynamics, and Materials Conference, 26th, Orlando, FL, April 15-17, 1985, Technical Papers. Part 2 . New York, American Institute of Aeronautics and Astronautics, 1985, p. 126-133. refs
(AIAA PAPER 85-0626)

Distributed segmented piezo-electric actuators bonded to an elastic sub-structure in flexure are modeled. A static shear-lag mechanical model for the interface between the piezo-electric and the sub-structure is developed. An example of the integration of the static piezo structure interaction into a simple dynamic model for the beam is given. This model leads to the ability to predict, a priori, the response of the structural member to an excitation voltage applied to the piezo-electric. The model is experimentally verified for the first several modes of an aluminum cantilevered beam with eight piezo-ceramics bonded near the root. A scaling analysis demonstrates that the effectiveness of the piezo-electric actuators scales with the structure, and allows the evaluation of candidate piezo-electric materials. Author

A85-30335#
OPTIMAL STRUCTURAL MODIFICATIONS TO ENHANCE THE OPTIMAL ACTIVE VIBRATION CONTROL OF LARGE FLEXIBLE STRUCTURES
N. S. KHOT, V. B. VENKAYYA (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH), and F. E. EASTEP (Dayton, University, Dayton, OH) IN: Structures, Structural Dynamics, and Materials Conference, 26th, Orlando, FL, April 15-17, 1985, Technical Papers. Part 2 . New York, American Institute of Aeronautics and Astronautics, 1985, p. 134-142. refs
(AIAA PAPER 85-0627)

This study provides a method of vibration control of large space structures by simultaneously integrating the structure and control design to reduce the structural response from a disturbance encountered. The formulation of the design scheme is obtained by the structural modification of some nominal finite element model, which is controlled in an optimal fashion by a linear regulator, to increase the active modal damping factor beyond that of the nominal structure. The structural modifications are achieved by using a nonlinear mathematical optimization technique. The objective function is the weight of the structure with a constraint on the damping parameter of the closed-loop system. The application of the algorithm is illustrated by designing an ACOSS-FOUR model with different constraint values. Author

A85-30336*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
A DESIGN TECHNIQUE FOR DETERMINING ACTUATOR GAINS IN SPACECRAFT VIBRATION CONTROL
G. C. HORNER and J. E. WALZ (NASA, Langley Research Center, Structural Dynamics Branch, Hampton, VA) IN: Structures, Structural Dynamics, and Materials Conference, 26th, Orlando, FL, April 15-17, 1985, Technical Papers. Part 2 . New York, American Institute of Aeronautics and Astronautics, 1985, p. 143-151. refs
(AIAA PAPER 85-0628)

A design procedure is described which determines the gains of a diagonal damping matrix to control the vibrations of a flexible structure with application to orbiting spacecraft. The procedure is

based on minimizing the energy dissipated by control actuators using nonlinear mathematical programming. Each damping gain is assumed to be an active viscous damper and the design process is formulated so that the force or torque output of the actuator does not exceed a specified value. The response of the structure at some specified time after the termination of the disturbance is constrained to be less than some prescribed value based upon spacecraft mission performance requirements. A grillage example is used to demonstrate the design process for determining gains for two representative cases. Resulting designs are verified by a finite element analysis of the structure augmented by the control actuators. Author

A85-30337#
LOW-AUTHORITY CONTROL SYNTHESIS FOR LARGE SPACECRAFT STRUCTURES, USING DISTURBANCE PROPAGATION CONCEPTS
A. H. VON FLOTOW (Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Wessling, West Germany) IN: Structures, Structural Dynamics, and Materials Conference, 26th, Orlando, FL, April 15-17, 1985, Technical Papers. Part 2 . New York, American Institute of Aeronautics and Astronautics, 1985, p. 152-160. USAF-supported research. refs
(AIAA PAPER 85-0630)

It is suggested that elastic deformation in large spacecraft structures can be viewed in terms of propagating disturbances. The active control of such structures would then be approached from the viewpoint of the active modification of natural disturbance propagation paths. Energy can be dissipated either by being shunted into unimportant portions of the structure or by using highly sophisticated active dampers which modify the open loop reflection coefficients of traveling structural wave modes. Computational examples are adduced which demonstrate the outstanding theoretical performance achievable by means of propagation-based controllers. O.C.

A85-30338#
COLLABORATIVE TECHNIQUES IN MODAL ANALYSIS
M. L. AMIROUCHE (Illinois, University, Chicago, IL) and R. L. HUSTON (Cincinnati, University, Cincinnati, OH) IN: Structures, Structural Dynamics, and Materials Conference, 26th, Orlando, FL, April 15-17, 1985, Technical Papers. Part 2 . New York, American Institute of Aeronautics and Astronautics, 1985, p. 161-165. refs
(AIAA PAPER 85-0632)

The present hybrid procedure for the determination of large structure vibrational characteristics combines modal analysis techniques with recently developed finite segment modeling methods. Experimental results from modal analysis and scaling procedures are used to establish the parameters for the finite segment model of the structure. Kane's (1980) equations are then applied to obtain the governing equations of motion. The procedure is applicable to structures exhibiting either linear or nonlinear flexibility and damping characteristics. O.C.

A85-30339#
STABILITY OF FLEXIBLE STRUCTURES WITH RANDOM PARAMETERS
F. KOZIN (New York, Polytechnic Institute, Brooklyn, NY) IN: Structures, Structural Dynamics, and Materials Conference, 26th, Orlando, FL, April 15-17, 1985, Technical Papers. Part 2 . New York, American Institute of Aeronautics and Astronautics, 1985, p. 166-172. refs
(Contract NSF CEE-83-11190)
(AIAA PAPER 85-0633)

It is demonstrated that sufficient conditions are obtainable for virtually certain asymptotic stability in continuous parameter systems that are optimal, in the sense that the Liapunov functional used yields the largest possible region of sufficiency. This functional is obtained by first appealing to the best sufficiency condition associated with nearly certain modal stability, and it is then translated into the proper operator which yields the Liapunov functional. These considerations apply to space structure control systems. O.C.

A85-30352#
STRUCTURAL DYNAMIC MODEL REDUCTION USING WORST CASE IMPULSE RESPONSE CRITERIA FOR LARGE FLEXIBLE SPACE STRUCTURES
A. S. S. R. REDDY (Howard University, Washington, DC) IN: Structures, Structural Dynamics, and Materials Conference, 26th, Orlando, FL, April 15-17, 1985, Technical Papers. Part 2 . New York, American Institute of Aeronautics and Astronautics, 1985, p. 262-265. refs
(AIAA PAPER 85-0684)

Attention is presently given to a situation in which a large, flexible space structure is subject to a finite impulse in all its degrees of freedom. The participation of the various modal coordinates in dynamic response are evaluated, with the dynamic response under an impulse in every degree of freedom being considered as the worst case and the modal coordinate participation being used as a criterion for the elimination of some of the model's modes. A finite element model of a hoop/column antenna is considered as an illustration of the reduction procedure. O.C.

A85-30354*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
IDENTIFYING APPROXIMATE LINEAR MODELS FOR SIMPLE NONLINEAR SYSTEMS
L. G. HORTA and J.-N. JUANG (NASA, Langley Research Center, Structural Dynamics Branch, Hampton, VA) IN: Structures, Structural Dynamics, and Materials Conference, 26th, Orlando, FL, April 15-17, 1985, Technical Papers. Part 2 . New York, American Institute of Aeronautics and Astronautics, 1985, p. 282-289. refs
(AIAA PAPER 85-0686)

This paper addresses the identification (realization) of approximate linear models from response data for certain nonlinear dynamic systems. Response characteristics for several typical nonlinear joints are analyzed mathematically and represented by series expansions. The parameters of the series expansion are then compared with the modal parameters of a linear model identified by the Eigensystem Realization Algorithm. The agreement of the identified model and the analytically derived representation is excellent for the cases studied. Also laboratory data from a model which exhibited stiffening behavior was analyzed using the Eigensystem Realization algorithm and Fast Fourier Transform. The laboratory experiment demonstrated the ability of the technique to recover the model characteristics using real data. Author

A85-30365#
GENERAL MOTION OF GYROELASTIC VEHICLES IN TERMS OF CONSTRAINED MODES
G. M. T. DELEUTERIO and P. C. HUGHES (Toronto, University, Downsview, Ontario, Canada) IN: Structures, Structural Dynamics, and Materials Conference, 26th, Orlando, FL, April 15-17, 1985, Technical Papers. Part 2 . New York, American Institute of Aeronautics and Astronautics, 1985, p. 384-390. refs
(AIAA PAPER 85-0731)

This paper develops the dynamical equations for the general motion of gyroelastic vehicles - vehicles modeled by a continuum of mass, stiffness and gyricity (stored angular momentum). The motion is expanded in terms of the vehicle's corresponding constrained modes. The associated eigenvalue problem reveals a significant departure from the modal behavior of nongyric elastic vehicles. In general, a gyroelastic vehicle exhibits a 'scleromorphic' mode in which the vehicle rotates uniformly in a deformed state. Although the frequency (eigenvalue) of this mode is zero, the stored strain energy associated with it is nonzero, and it is therefore not a 'rigid-body' mode. Author

A85-30371#
ELECTRONIC DAMPING TECHNIQUES AND ACTIVE VIBRATION CONTROL
S. HANAGUD, M. W. OBAL, and M. MEYYAPPA (Georgia Institute of Technology, Atlanta, GA) IN: Structures, Structural Dynamics, and Materials Conference, 26th, Orlando, FL, April 15-17, 1985, Technical Papers. Part 2 . New York, American Institute of Aeronautics and Astronautics, 1985, p. 443-453. refs
(Contract DAAG29-82-K-0094)
(AIAA PAPER 85-0752)

Techniques for the quantitative identification of the changes introduced in the damping matrix of a cantilever beam by a piezoceramic-transducer velocity-feedback active electronic vibration-control system are developed. The principles of active damping feedback theory are reviewed; the system-matrix x-identification procedure is derived analytically; the experimental setup and data-acquisition protocol are described; a finite-element model of the beam is constructed; and the theoretical, finite-element, and experimental results are presented in tables and graphs and characterized. Consideration is given to the sensitivity of the identification technique, and applications to the design of large space structures are indicated. T.K.

A85-30372*# Duke Univ., Durham, N. C.
DIRECT COMPUTATION OF OPTIMAL CONTROL OF FORCED LINEAR SYSTEM
S. UTKU (Duke University, Durham, NC), C.-P. KUO, and M. SALAMA (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, CA) IN: Structures, Structural Dynamics, and Materials Conference, 26th, Orlando, FL, April 15-17, 1985, Technical Papers. Part 2 . New York, American Institute of Aeronautics and Astronautics, 1985, p. 454-458. NASA-supported research. refs
(AIAA PAPER 85-0753)

It is known that the optimal control of a forced linear system may be reduced to that of tracking the system without forces. The solution of the tracking problem is available via the costate variables method. This procedure is computationally expensive for large order systems. It requires solution of matrix Riccati equation and two final value problems. An alternate approach is outlined for the direct computation of the optimal control. Instead of Riccati equation, a matrix Volterra integral must be solved. For this purpose two computational schemes are described, and an illustrative example is given. The results compare favorably with the classical solution. This alternative approach may be especially useful for the control of large space structure where large order models are required. Author

A85-30375*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
EXTENSION OF GROUND-BASED TESTING FOR LARGE SPACE STRUCTURES
B. K. WADA, C. P. KUO, and R. J. GLASER (California Institute of Technology, Jet Propulsion Laboratory, Applied Mechanics Technology Section, Pasadena, CA) IN: Structures, Structural Dynamics, and Materials Conference, 26th, Orlando, FL, April 15-17, 1985, Technical Papers. Part 2 . New York, American Institute of Aeronautics and Astronautics, 1985, p. 477-483. NASA-supported research. refs
(AIAA PAPER 85-0757)

A major concern for future large space structures is the ability to verify their dynamic characteristics by ground test. This article presents the results of the multiple boundary conditions test (MBCT) approach, which provides a complete ground test of a large structure that will provide, in turn, the data necessary to construct a test-verified final mathematical model. Theoretical studies indicate that this approach can provide a better final model than a ground test of the full-scale very flexible structure in a 1-g field. The approach is demonstrated by a mathematical simulation. Author

A85-30376#
EXPERIMENTAL SUBSTRUCTURE COUPLING WITH ROTATIONAL COUPLING COORDINATES
Y.-T. CHUNG (Bell Helicopter Textron, Fort Worth, TX) and R. R. CRAIG, JR. (Texas, University, Austin, TX) IN: Structures, Structural Dynamics, and Materials Conference, 26th, Orlando, FL, April 15-17, 1985, Technical Papers. Part 2 . New York, American Institute of Aeronautics and Astronautics, 1985, p. 484-489. refs
(AIAA PAPER 85-0759)

A technique for coupling substructures in the construction of mathematical models of large structures using experimental data which include rotational coordinates is developed and demonstrated. Multiple-degree-of-freedom curve fitting is employed to determine the modal frequencies and translational mode shapes from the measured translational frequency-response functions (FRFs), and the corresponding rotational modal displacements at the interface are calculated directly with a cubic-spline curve-fitting algorithm, eliminating the need to determine rotational FRFs. The technique is applied to simulated data for a 12-degree-of-freedom fixed-fixed beam problem, and the results are presented in tables and graphs and shown to be in good agreement with analytical solutions obtained with the finite-element method. The present technique requires fewer FRF data points than the finite-difference method for the same degree of accuracy. T.K.

A85-30381#
INERTIAL ACTUATOR DESIGN FOR MAXIMUM PASSIVE AND ACTIVE ENERGY DISSIPATION IN FLEXIBLE SPACE STRUCTURES
D. W. MILLER, E. F. CRAWLEY, and B. A. WARD (MIT, Cambridge, MA) IN: Structures, Structural Dynamics, and Materials Conference, 26th, Orlando, FL, April 15-17, 1985, Technical Papers. Part 2 . New York, American Institute of Aeronautics and Astronautics, 1985, p. 536-544. refs
(AIAA PAPER 85-0777)

The design of passive and active inertial vibration absorbers for large flexible space structures is investigated analytically and experimentally. Three different parameter-optimization techniques are shown to lead to nearly identical optimal passive-absorber designs for sample systems with one or two degrees of freedom, suggesting that the frequency of a low-mass-ratio absorber is best tuned near the lowest mode of interest before adjusting the damper to balance damping between modes. Active actuators designed by a sequential optimization scheme which optimizes first the passive parameters and then the regulator gains are found to give the same performance as those designed by a more complicated simultaneous scheme. The results of experiments using electromagnetic inertial-reaction actuators on a quasi-free-free beam are presented graphically, and significant damping (approaching theoretical limits for a single mode) is observed, indicating the applicability of both the theoretical approach and the technology. T.K.

A85-30383#
DAMPING SYNTHESIS FOR FLEXIBLE SPACE STRUCTURES USING COMBINED EXPERIMENTAL AND ANALYTICAL MODELS
M. L. SONI (Dayton, University, Dayton, OH) and B. N. AGRAWAL (International Telecommunications Satellite Organization, Washington, DC) IN: Structures, Structural Dynamics, and Materials Conference, 26th, Orlando, FL, April 15-17, 1985, Technical Papers. Part 2 . New York, American Institute of Aeronautics and Astronautics, 1985, p. 552-558. Research supported by the International Telecommunications Satellite Organization. refs
(AIAA PAPER 85-0779)

A damping synthesis procedure specifically addressing the problem of joint subsystems in flexible space structures is presented. The method combined the best features of conventional matrix and energy methods for modal and damping analysis on the basis of subsystem tests and/or analyses. The formulation of the synthesis procedure is described. A representative flexible

spacecraft appendage incorporating realistic deployable joints is analyzed in order to verify the accuracy of the procedure. I.H.

A85-30385*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
A CONCURRENT PROCESSING IMPLEMENTATION FOR STRUCTURAL VIBRATION ANALYSIS
S. W. BOSTIC (NASA, Langley Research Center, Structural Mechanics Branch, Hampton, VA) and R. E. FULTON (NASA, Langley Research Center; Joint Institute for Advancement of Flight Sciences, Hampton, VA) IN: Structures, Structural Dynamics, and Materials Conference, 26th, Orlando, FL, April 15-17, 1985, Technical Papers. Part 2 . New York, American Institute of Aeronautics and Astronautics, 1985, p. 566-572. refs
(AIAA PAPER 85-0783)

A concurrent processing algorithm for analysis of large aerospace structures is presented. A general description of the implementation criteria for the algorithm is given, and the results from applications to two vibration test problems are discussed. The test problems included a flexural vibration analysis of a long beam with 16 uniformly spaced supports, and a torsional vibration analysis. The computer system used to implement the algorithm was an experimental MIND system. The concurrent processing speedups for the test problems are given in a table. I.H.

A85-30392#
INTEGRATED STRUCTURAL/CONTROL SYNTHESIS VIA SET-THEORETIC METHODS
A. L. HALE (General Dynamics Corp., Convair Div., San Diego, CA) IN: Structures, Structural Dynamics, and Materials Conference, 26th, Orlando, FL, April 15-17, 1985, Technical Papers. Part 2 . New York, American Institute of Aeronautics and Astronautics, 1985, p. 636-641. refs
(AIAA PAPER 85-0806)

This paper considers an ellipsoidal set-theoretic approach to the integrated structural/control synthesis for vibration regulation of flexible structures such as large space structures. The synthesis attempts to maximize the allowable magnitude of an unknown but bounded disturbance to the structure while explicitly satisfying specific input and output constraints. Both structural parameters and control gains are variable during a search for the maximum allowable disturbance. A simple numerical example is presented to illustrate this synthesis approach. Author

A85-30393*# Virginia Polytechnic Inst. and State Univ., Blacksburg.
SENSITIVITY OF OPTIMIZED CONTROL SYSTEMS TO MINOR STRUCTURAL MODIFICATIONS
R. T. HAFTKA, Z. N. MARTINOVIC, W. L. HALLAUER, JR., and G. SCHAMEL (Virginia Polytechnic Institute and State University, Blacksburg, VA) IN: Structures, Structural Dynamics, and Materials Conference, 26th, Orlando, FL, April 15-17, 1985, Technical Papers. Part 2 . New York, American Institute of Aeronautics and Astronautics, 1985, p. 642-650. refs
(Contract NAG1-224)
(AIAA PAPER 85-0807)

A procedure for checking whether small changes in a structure have the potential for significant enhancements of its optimized vibration control system is described. The first step in the procedure consists of the calculation of the sensitivity of the parameters of the optimized control system to small changes in the structural parameters. Theh second step consists of the optimization of the structural parameters to produce maximal increase in the performance of the control system with minimal change in the structure. The procedure has been demonstrated for a flexible laboratory structure controlled by several rate-feedback colocated force-actuator velocity-sensor pairs. Significant improvements in the performance of the control system were obtained with small structural modifications. Analytical predictions of such effects have also been validated experimentally. Author

A85-30400*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
COMPARATIVE ANALYSIS OF ON-ORBIT DYNAMIC PERFORMANCE OF SEVERAL LARGE ANTENNA CONCEPTS
G. C. ANDERSEN, L. B. GARRETT (NASA, Langley Research Center, Space Systems Div., Hampton, VA), and R. E. CALLESON (Kentron International, Inc., Hampton, VA) IN: Structures, Structural Dynamics, and Materials Conference, 26th, Orlando, FL, April 15-17, 1985, Technical Papers. Part 2 . New York, American Institute of Aeronautics and Astronautics, 1985, p. 707-722. refs
(AIAA PAPER 85-0818)

A comparative analysis of the on-orbit dynamic performance of four large anetanna concepts is presented. Among the antenna concepts evaluated are: the box truss; tetrahedral truss; warp-radial rib; and the hoop and column antenna designs. The characteristics and magnitudes of the antennas' dynamic response were evaluated in terms of structural displacements and member loads incurred during various slew-rate maneuvers. The results of the dynamic response analysis are compared to the design requirements of the Land Mobile Satellite System (LMSS) with respect to surface accuracy, decenter, defocus, and angular rocking. Comments are made on the effectiveness of structural damping and the application of active controls for vibrational response reduction. Schematic illustrations of the antenna design concepts are provided. I.H.

A85-30401*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
DYNAMIC CHARACTERISTICS OF STATICALLY DETERMINATE SPACE-TRUSS PLATFORMS
M. S. ANDERSON (NASA, Langley Research Center, Structures and Dynamics Div., Hampton, VA) and N. A. NIMMO IN: Structures, Structural Dynamics, and Materials Conference, 26th, Orlando, FL, April 15-17, 1985, Technical Papers. Part 2 . New York, American Institute of Aeronautics and Astronautics, 1985, p. 723-728. refs
(AIAA PAPER 85-0819)

The geometry of a class of statically determinate platforms is developed and vibration frequencies determined. Such configurations would allow shape control by changing member lengths to be accomplished with small forces. An additional advantage of a statically determinate structure is being free of thermal stress under any temperature distribution. Frequency comparisons between statically determinate and more conventional redundant platforms are presented. Vibration of curved platforms that could be used as antenna concepts is also investigated. Alternate concepts incorporating the statically determinate design but having improved dynamic characteristics are suggested. Author

A85-30402#
DYNAMICS AND CONTROL OF A LARGE DEPLOYABLE REFLECTOR
G. J. BALAS (California Institute of Technology, Pasadena, CA) and R. SHEPHERD (California, University, Irvine, CA) IN: Structures, Structural Dynamics, and Materials Conference, 26th, Orlando, FL, April 15-17, 1985, Technical Papers. Part 2 . New York, American Institute of Aeronautics and Astronautics, 1985, p. 729-734. Research supported by the McDonnell Douglas Astronautics Co.
(AIAA PAPER 85-0820)

The problem of passively controlling structural deformations in a large deployable reflector by adding damping to the system is reviewed. The results of modeling a large deployable reflector with PATRAN-G and analysing it with EASE2 and MSC/NASTRAN finite element codes are reported. The first ten asymmetric and symmetric mode shapes and natural frequencies are determined. The application of symmetry and the replacement of the mirror reflectors with lumped masses enables a substantial reduction in the amount of computer time to be achieved without loss of accuracy. Following identification of the dynamic characteristics of the structure, sensitivity analyses enable determination to be made of the optimal placement of passive damping elements to decrease the structural deformations of the reflector structure. Author

A85-30404#
OPTIMIZATION USING LATTICE PLATE FINITE ELEMENTS FOR FEEDBACK CONTROL OF SPACE STRUCTURES
T. Y. YANG (USAF, Washington, DC) and S. E. LAMBERSON (Purdue University, West Lafayette, IN) IN: Structures, Structural Dynamics, and Materials Conference, 26th, Orlando, FL, April 15-17, 1985, Technical Papers. Part 2 . New York, American Institute of Aeronautics and Astronautics, 1985, p. 743-750. refs
(Contract AF-AFOSR-83-0104)
(AIAA PAPER 85-0592)

Lattice plate finite elements based on a continuum model of a large plate-like lattice space structure are used to examine the effect of variation of several fundamental structural parameters on the natural frequencies and mode shapes of the structure. Reduced order controller design models are developed using modal cost analysis to rank the modes for each set of structural parameter values. The linear quadratic Gaussian (LQG) controller design method is used to develop feeback control systems for each set of structural parameter values. The resulting system performance is then evaluated by examining the steady state regulation cost of the structure as a function on the structural design parameters.
Author

A85-30408*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
APPLICATION OF SINGULAR VALUE DECOMPOSITION TO STRUCTURAL DYNAMICS SYSTEMS WITH CONSTRAINTS
J.-N. JUANG and L. D. PINSON (NASA, Langley Research Center, Hampton, VA) AIAA, ASME, ASCE, and AHS, Structures, Structural Dynamics, and Materials Conference, 26th, Orlando, FL, Apr. 15-17, 1985. 7 p. refs
(AIAA PAPER 85-0687)

Singular value decomposition is used to construct a coordinate transformation for a linear dynamic system subject to linear, homogeneous constraint equations. The method is compared with two commonly used methods, namely classical Gaussian elimination and Walton-Steeves approach. Although the classical method requires fewer numerical operations, the singular value decomposition method is more accurate and convenient in eliminating the dependent coordinates. Numerical examples are presented to demonstrate the application of the method. Author

A85-30409*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
NONLINEAR DYNAMIC ANALYSIS OF DEPLOYING FLEXIBLE SPACE BOOMS
P. E. MCGOWAN and J. M. HOUSNER (NASA, Langley Research Center, Structures and Dynamics Div., Hampton, VA) AIAA, ASME, ASCE, and AHS, Structures, Structural Dynamics, and Materials Conference, 26th, Orlando, FL, Apr. 15-17, 1985. 13 p. refs
(AIAA PAPER 85-0594)

The dynamics of the planar deployment and lock-up of two flexible boom-type appendages on a spacecraft are analyzed by establishing nonlinear equations of motion for the deployment phase and linear for the post-lock-up phase. Nondimensional parameters and threshold values are identified in terms of boom tip deflections, deployment time and root moments for appendages with tip masses attached to a central rigid body through a rotational spring; an account is taken of the nonlinear kinematic and structural terms. It was found that, in general, the solution is influenced only by two mass ratios and one nondimensional stiffness parameter. L.T.

A85-31184
TURBULENT DIFFUSION FROM SOURCES IN COMPLEX FLOWS
J. C. R. HUNT (Cambridge University, Cambridge, England) IN: Annual review of fluid mechanics. Volume 17 . Palo Alto, CA, Annual Reviews, Inc., 1985, p. 447-485. Research sponsored by the Department of Natural Resources of Maryland and NOAA. refs

Current analytic models for the basic mechanisms of the dispersion of heat and matter from localized sources in turbulent flows are outlined. The flows are characterized by homogeneity, unsteady turbulence, shear, convergence and divergence, non-gaussian turbulent structures, mean flow recirculation and nearby surfaces. Attention is given to the connections between the mean pollutant concentration and the statistics of displacements of fluid elements, the latter in the form of converging, diverging and shear flows. Inhomogeneity across the plume is considered, along with diffusion near surfaces. Finally, random flight models are discussed for the case of complex flows, e.g. around buildings and hills. M.S.K.

A85-32785*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
DYNAMICS AND CONTROL OF A SHUTTLE-ATTACHED ANTENNA EXPERIMENT
S. J. WANG, Y. H. LIN, and C.-H. C. IH (California Institute of Technology, Jet Propulsion Laboratory, Automation and Energy Systems Div., Pasadena, CA) (Guidance and Control Conference, Gatlinburg, TN, August 15-17, 1983, Collection of Technical Papers, p. 466-477) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 8, May-June 1985, p. 344-353. NASA-supported research. Previously cited in issue 19, p. 2816, Accession no. A83-41707. refs

A85-32788#
MODAL-SPACE ACTIVE DAMPING OF A PLANE GRID - EXPERIMENT AND THEORY
WM. L. HALLAUER, JR., G. R. SKIDMORE, and R. N. GEHLING (Virginia Polytechnic Institute and State University, Blacksburg, VA) (Structures, Structural Dynamics and Materials Conference, 25th, Palm Springs, CA, May 14-16, 1984, and AIAA Dynamics Specialists Conference, Palm Springs, CA, May 17, 18, 1984, Technical Papers. Part 2, p. 306-316) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 8, May-June 1985, p. 366-373. Previously cited in issue 13, p. 1914, Accession no. A84-31717. refs
(Contract AF-AFOSR-82-0217; NSF CME-80-14059; F49620-83-C-0158)

A85-32789#
DEVELOPMENT OF DYNAMICS AND CONTROL SIMULATION OF LARGE FLEXIBLE SPACE SYSTEMS
J. Y. L. HO and D. R. HERBER (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) (Guidance and Control Conference, San Diego, CA, August 9-11, 1982, Collection of Technical Papers, p. 367-378) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 8, May-June 1985, p. 374-383. Previously cited in issue 02, p. 141, Accession no. A83-12456. refs

A85-32792#
USE OF FREQUENCY DEPENDENCE IN LINEAR QUADRATIC CONTROL PROBLEMS TO FREQUENCY-SHAPE ROBUSTNESS
B. D. O. ANDERSON (Australian National University, Canberra, Australia) and D. L. MINGORI (California, University, Los Angeles, CA) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 8, May-June 1985, p. 397-401. refs

Linear quadratic control problems are considered where frequency-dependent weighting on the control is assumed. When high frequencies are weighted more heavily than low frequencies, two qualitative conclusions can be drawn: passband robustness is reduced and high-frequency robustness is improved. The result gives a theoretical underpinning to the use of frequency-dependent weighting when high-frequency uncertainty is present in the plant.
Author

A85-32797*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
RELIABILITY CONSIDERATIONS IN THE PLACEMENT OF CONTROL SYSTEM COMPONENTS
R. C. MONTGOMERY (NASA, Langley Research Center, Spacecraft Control Branch, Hampton, VA) and W. E. VANDER VELDE (MIT, Cambridge, MA) (Guidance and Control Conference, Gatlinburg, TN, August 15-17, 1983, Collection of Technical Papers, p. 660-664) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 8, May-June 1985, p. 411-413. Previously cited in issue 19, p. 2816, Accession no. A83-41730. refs

A85-33270
DISCRETE-TIME OPTIMAL CONTROL OF FLEXIBLE STRUCTURES
J. S. GIBSON and F. JABBARI (California, University, Los Angeles, CA) IN: Conference on Decision and Control, 22nd, San Antonio, TX, December 14-16, 1983, Proceedings. Volume 1 . New York, Institute of Electrical and Electronics Engineers, Inc., 1983, p. 286-290.
(Contract NSF ENG-78-04753)

Approximation of an ideal infinite dimensional compensator for an infinite dimensional system is discussed. Two approaches are considered; one is to design a compensator for a finite dimensional model of the system, and the other approach, which is stressed here, is to truncate an infinite dimensional ARMA representation of the ideal compensator. Performance of the closed-loop system is discussed, and an example from control of flexible structures is presented. Author

A85-33288
DESIGN OF AN EXACT NONLINEAR MODEL FOLLOWER FOR THE CONTROL OF LARGE ANGLE ROTATIONAL MANEUVERS
T. A. W. DWYER, III (Colorado State University, Fort Collins, CO) IN: Conference on Decision and Control, 22nd, San Antonio, TX, December 14-16, 1983, Proceedings. Volume 2 . New York, Institute of Electrical and Electronics Engineers, Inc., 1983, p. 803-807. refs
(Contract NSF ECS-83-04968; F4920-83-K-0032)

The rigid body attitude control problem with external torques is transformed into equivalent linear form implementable by three double integrators. The linearizing transformations themselves are formulated in vector algebra, requiring no integrators for implementation. It is thereby shown that optimal command generation for fast slewing maneuvers can be carried out exactly in the transformed systems, together with regulator design without gain scheduling for correction of unmodeled disturbances. Author

A85-33289
DYNAMICS OF ROTATING FLEXIBLE STRUCTURES
J. BAILLIEUL (Scientific Systems, Inc., Cambridge, MA) and M. LEVI (Boston University, Boston, MA) IN: Conference on Decision and Control, 22nd, San Antonio, TX, December 14-16, 1983, Proceedings. Volume 2 . New York, Institute of Electrical and Electronics Engineers, Inc., 1983, p. 808-813. refs
(Contract NSF ECS-81-18213; NSF ECS-81-18138)

The dynamics of rotating flexible structures are described by nonlinear hybrid systems of coupled ordinary and partial differential equations. These equations are derived for a certain class of structures which has been chosen for study in the belief that it displays all the important dynamical features to be encountered with any flexible structure. When structural damping is present, and there are no external torques, there is a set of equilibrium states toward which all trajectories of the system evolve. This set is studied in some detail, and it is shown how the steady state dynamics may be completely characterized. A brief stability analysis is given which indicates how a rotating structure settles down to an equilibrium. Author

A85-33290
LIE POISSON STRUCTURES AND DUAL-SPIN SPACECRAFT
P. S. KRISHNAPRASAD (Maryland, University, College Park, MD) IN: Conference on Decision and Control, 22nd, San Antonio, TX, December 14-16, 1983, Proceedings. Volume 2 . New York, Institute of Electrical and Electronics Engineers, Inc., 1983, p. 814-824. refs
(Contract DE-AC01-80RA-50420-A001; NSF ECS-81-18138)

It is pointed out that a dual-spin spacecraft may be viewed as a simple spinning platform carrying a motor-driven symmetric rigid rotor. The motor is spun up to a desired angular velocity relative to the platform and then it is maintained at this constant angular velocity. In the presence of a suitable damping mechanism, and for sufficiently high rotor angular velocities, one can expect the sacecraft angular momentum vector to align itself eventually with the rotor axis. Problems arise, however, with the analytical verification of this concept. The present investigation is concerned with the dynamics of rigid spacecraft carrying three (motor driven or free spinning) rotors. The investigation was motivated by the problem of analytic verification of certain design conditions for dual-spin spacecraft known to aerospace engineers. Attention is given to the underlying Lie-Poisson structures for the considered spacecraft. G.R.

A85-33291
THE OPTIMAL CONTROL OF FLEXIBLE SYSTEMS USING A CONVOLUTION INTEGRAL DESCRIPTION OF MOTION
S. B. SKAAR and D. TUCKER (Iowa State University of Science and Technology, Ames, IA) IN: Conference on Decision and Control, 22nd, San Antonio, TX, December 14-16, 1983, Proceedings. Volume 2 . New York, Institute of Electrical and Electronics Engineers, Inc., 1983, p. 825-829. refs

In recent years, considerable attention has been given to the problem of controlling flexible systems. Most of the suggested control schemes have approximate characteristics since unmodeled modes are neglected. The present investigation is concerned with an approach which can be used to determine exact open-loop optimal control solutions in which a finite number of locations within a flexible system may be brought to a desired final position and velocity. The form of the solution is a convergent infinite series of time-varying terms. The truncation of the series introduces an error, but the magnitude of this error can be easily determined. The method is demonstrated with the aid of a simple satellite model. A convolution integral derivation is provided. G.R.

A85-33440*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
FLEXIBILITY OF SPACE STRUCTURES MAKES DESIGN SHAKY
D. P. HEARTH and W. J. BOYER (NASA, Langley Research Center, Hampton, VA) Aerospace America (ISSN 0740-722X), vol. 23, May 1985, p. 100-103.

An evaluation is made of the development status of high stiffness space structures suitable for orbital construction or deployment of large diameter reflector antennas, with attention to the control system capabilities required by prospective space structure system types. The very low structural frequencies typical of very large, radio frequency antenna structures would be especially difficult for a control system to counteract. Vibration control difficulties extend across the frequency spectrum, even to optical and IR reflector systems. Current research and development efforts are characterized with respect to goals and prospects for success. O.C.

A85-33616
FREE VIBRATION CONTINUUM MODEL FOR A FLEXIBLE, WRAP-RIB ANTENNA
D. B. SCHAECHTER (Lockheed Palo Alto Research Laboratory, Palo Alto, CA) Journal of the Astronautical Sciences (ISSN 0021-9142), vol. 33, Jan.-Mar. 1985, p. 3-14.

The Lockheed wrap-rib antenna is one of several antenna designs currently being considered for a variety of earth-orbiting communications applications. The dynamic characteristics of this

generic type of antenna determine the pointing accuracy and the limiting radio frequency (RF) quality of the antenna signal. In this paper, a continuum (partial differential equation or pde) model is developed for the flexible, wrap-rib antenna. The pde model provides a convenient method for obtaining a concisely written representation of the motions of the antenna, a mechanism for gaining physical insight into its dynamics, and a method for performing parametric studies of the antenna. When this pde modeling technique is applied to a specific example, excellent agreement between the pde model and a high-order finite element model is obtained, and with only a small fraction of the modeling and computational requirements of finite element methods.
Author

A85-33617
FREQUENCIES OF VIBRATION ESTIMATED BY LATTICES
D. M. WIBERG (California, University, Los Angeles, CA) Journal of the Astronautical Sciences (ISSN 0021-9142), vol. 33, Jan.-Mar. 1985, p. 63-69. refs

Lattice form recursive linear least-squares algorithms (lattices, for short) are inherently numerically stable, recursive in system order, and have a history of successful identification of autoregressive processes. If vibrations are free or forced with white noise, then the associated equations of motion are autoregressive and lattices are an appropriate tool for their identification. A slight modification of the multi-process lattice is derived to estimate frequencies of vibration. Appropriate procedures are given to test if assumptions about the system are satisfied. Given the frequencies of vibration, a least squares estimate of the modes is presented for the free (unforced) case. Author

A85-33618* Stanford Univ., Calif.
THE EXPERIMENTAL RESULTS OF A SELF TUNING ADAPTIVE CONTROLLER USING ONLINE FREQUENCY IDENTIFICATION
W.-W. CHIANG and R. H. CANNON, JR. (Stanford University, Stanford, CA) (NASA Workshop on Identification and Control of Flexible Space Structures, San Diego, CA, June 4-6, 1984) Journal of the Astronautical Sciences (ISSN 0021-9142), vol. 33, Jan.-Mar. 1985, p. 71-83. NASA-sponsored research. refs

A fourth-order laboratory dynamic system featuring very low structural damping and a noncolocated actuator-sensor pair has been used to test a novel real-time adaptive controller, implemented in a minicomputer, which consists of a state estimator, a set of state feedback gains, and a frequency-locked loop for real-time parameter identification. The adaptation algorithm employed can correct controller error and stabilize the system for more than 50 percent variation in the plant's natural frequency, compared with a 10 percent stability margin in frequency variation for a fixed gain controller having the same performance as the nominal plant condition. The very rapid convergence achievable by this adaptive system is demonstrated experimentally, and proven with simple, root-locus methods. O.C.

A85-33619* Jet Propulsion Lab., California Inst. of Tech., Pasadena.
IDENTIFIABILITY OF CONSERVATIVE LINEAR MECHANICAL SYSTEMS
S. W. SIRLIN (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, CA), R. W. LONGMAN (Columbia University, New York, NY), and J. N. JUANG (NASA, Langley Research Center, Hampton, VA) Journal of the Astronautical Sciences (ISSN 0021-9142), vol. 33, Jan.-Mar. 1985, p. 95-118. refs
(Contract NSF CEE-80-19275)

With a sufficiently great number of sensors and actuators, any finite dimensional dynamic system is identifiable on the basis of input-output data. It is presently indicated that, for conservative nongyroscopic linear mechanical systems, the number of sensors and actuators required for identifiability is very large, where 'identifiability' is understood as a unique determination of the mass and stiffness matrices. The required number of sensors and actuators drops by a factor of two, given a relaxation of the identifiability criterion so that identification can fail only if the system parameters being identified lie in a set of measure zero. When the mass matrix is known a priori, this additional information does not significantly affect the requirements for guaranteed identifiability, though the number of parameters to be determined is reduced by a factor of two. O.C.

A85-35162
ON THE STABILITY PROBLEM CAUSED BY FINITE ACTUATOR DYNAMICS IN THE COLLOCATED CONTROL OF LARGE SPACE STRUCTURES
C. J. GOH (Sydney, University, Sydney, Australia) and T. K. CAUGHEY (California Institute of Technology, Pasadena, CA) International Journal of Control (ISSN 0020-7179), vol. 41, March 1985, p. 787-802. refs

As large space structures are basically distributed systems, serious consideration must be given to the very high order, and consequently very high bandwidth, of these systems. In particular, as practical active control devices such as sensors and actuators have finite bandwidth, great care must be exercised so that control of low-frequency modes does not destabilize the intermediate and higher-order modes. In this paper, the nature of these stability problems is investigated and a technique using position feedback is considered. Author

A85-35163
A QUASI-LINEAR VIBRATION SUPPRESSION TECHNIQUE FOR LARGE SPACE STRUCTURES VIA STIFFNESS MODIFICATION
C. J. GOH (Sydney, University, Sydney, Australia) and T. K. CAUGHEY (California Institute of Technology, Pasadena, CA) International Journal of Control (ISSN 0020-7179), vol. 41, March 1985, p. 803-812. refs

The feasibility of conventional actuators is discussed and alternative means of electronic damping are suggested. The concept of stiffness modification is introduced and applied to the vibration suppression of a multivariate oscillatory system. Despite the relatively simple structure of the control scheme, global stability is always guaranteed by virtue of the positive definite rate of energy decay. Author

A85-35348* Drexel Univ., Philadelphia, Pa.
OPTIMAL OUTPUT FEEDBACK DESIGN OF SYSTEMS WITH ILL-CONDITIONED DYNAMICS
A. J. CALISE and D. D. MOERDER (Drexel University, Philadelphia, PA) Automatica (ISSN 0005-1098), vol. 21, May 1985, p. 271-276. refs
(Contract NAG1-243)

Singular perturbation concepts are exploited to develop a procedure for designing a constant gain, output feedback control system. It is assumed that the original system is ill-conditioned in the sense that the plant contains widely separated dynamics, and that an accurate description for the high frequency behavior may not be available. The design procedure attempts to stabilize the system by minimizing a quadratic cost function made up of the control and states associated with a reduced order (low frequency) model for the plant, and a measure of stability for the neglected fast dynamics. The resulting design procedure does not require knowledge of the fast dynamics. Author

A85-35977*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
PROGRESS IN ADAPTIVE CONTROL OF FLEXIBLE SPACECRAFT USING LATTICE FILTERS
N. SUNDARARAJAN (Old Dominion University, Hampton, VA) and R. C. MONTGOMERY (NASA, Langley Research Center, Hampton, VA) Workshop on Applications of Adaptive Control, Yale University, New Haven, CT, May 29-31, 1985, Paper. 7 p. refs

This paper reviews the use of the least square lattice filter in adaptive control systems. Lattice filters have been used primarily in speech and signal processing, but they have utility in adaptive control because of their order-recursive nature. They are especially useful in dealing with structural dynamics systems wherein the order of a controller required to damp a vibration is variable depending on the number of modes significantly excited. Applications are presented for adaptive control of a flexible beam.

Also, difficulties in the practical implementation of the lattice filter in adaptive control are discussed. Author

A85-35983#
EXPERIMENTAL EVALUATION OF FLEXIBLE STRUCTURE IDENTIFICATION USING LATTICE FILTERS
N. SUNDARARAJAN (Old Dominion University Research Foundation, Hampton, VA) International Federation of Automatic Control, Symposium on Identification and System Parameter Estimation, 7th, York, England, July 2-8, 1985, Paper. 7 p. refs

This paper presents the use of least square lattice filters in identification of the dynamics of highly flexible structures. Lattice filters have been used extensively in the areas of adaptive signal processing and speech synthesis. Herein, they are used for on-line identification of the number of modes, mode shapes and modal amplitude time series from the measurement data. The theory is illustrated using experimental data for a simple free-free beam and a more complex, flexible, two-dimensional grid apparatus. Results presented indicate that the lattice filter approach produces effective identification of structural dynamics for the class of structures studied to this time. Author

A85-36909
DYNAMIC CONSIDERATIONS FOR CONTROL OF CLOSED LIFE SUPPORT SYSTEMS
P. S. BABCOCK, D. M. AUSLANDER, and R. C. SPEAR (California, University, Berkeley, CA) (COSPAR, Workshops on Life Sciences and Space Research XXI/2/, 7th and 11th, Graz, Austria, June 25-July 7, 1984) Advances in Space Research (ISSN 0273-1177), vol. 4, no. 12, 1984, p. 263-270. refs

Reliability of closed life support systems will depend on their ability to continue supplying the crew's needs in the face of perturbations and equipment failures. These dynamic considerations interact with the basic static (equilibrium) design through the sizing of storages, the specification of excess capacities in processors, and the choice of system initial state (total mass in the system). This paper uses a very simple system flow model to examine the possiblities for system failures even when there is sufficient storage to buffer the immediate effects of the perturbation. Two control schemes are shown which have different dynamic consequences in response to component failures. Author

A85-37196*# Drexel Univ., Philadelphia, Pa.
TWO TIME SCALE DESIGN OF OUTPUT FEEDBACK SYSTEMS
A. J. CALISE and D. D. MOERDER (Drexel University, Philadelphia, PA) IN: Israel Annual Conference on Aviation and Astronautics, 26th, Haifa, Israel, February 8, 9, 1984, Collection of Papers . Haifa, Israel, Technion - Israel Institute of Technology, 1984, p. 153-158. refs
(Contract NAG1-243)

Singular perturbation techniques are used in this paper to develop a two time scale procedure for designing static gain output feedback controllers. It is shown that, if certain control spillover conditions are satisfied, control designs based on reduced-order models will stabilize the corrgsponding full system. Optimal output feedback control theory is used to derive the necessary conditions for the stabilizing gain matrix. The problem of stabilizing a model for a large space structure is used to illustrate the practicality of the approach. Author

A85-37274#
A DISTRIBUTED-ELEMENT METHOD FOR VIBRATION ANALYSIS OF FLEXIBLE SPACECRAFT BASED ON TRANSFER MATRICES
M. DAVIES (Surrey, University, Guildford, England) and B. DAWSON (Kingston Polytechnic, Kingston-on-Thames, Surrey, England) ESA Journal (ISSN 0379-2285), vol. 9, no. 1, 1985, p. 75-95. refs

The transfer matrix method for the vibration analysis of flexible spacecraft is described. It is shown that the method uses the same distributed-element formulation as the impedance-matrix method, but is pole-free. To assemble an asymmetric characteristic matrix, the zeros of whose determinant are the natural vibration frequencies of the structure, a graph-theoretic representation of the structure is used. By computing the cantilever and free torsional modes of the Space-Telescope solar-array distributed-element model, the feasibility of the transfer matrix method is demonstrated. The results are found to be identical, to full machine precision, with those obtained in the impedance-matrix test cases. M.D.

A85-37439
SUBSTRUCTURE SYNTHESIS METHODS FOR DYNAMIC ANALYSIS OF MULTI-BODY SYSTEMS
A. A. SHABANA (Illinois, University, Chicago, IL) Computers and Structures (ISSN 0045-7949), vol. 20, no. 4, 1985, p. 737-744. refs

The formulation for the dynamic analysis of flexible multi-body systems that undergo large rigid body motion, leads to geometrically non-linear inertia properties due to large rotations. These inertia non-linearities that represent the coupling between gross rigid body motion and small elastic deformation, are dependent on the assumed displacement field. As alternatives to the finite element methods, deformable body shape functions and shape vectors are commonly employed to describe elastic deformation of linear structures. In this paper, substructure shape functions and shape vectors are used to describe elastic deformation of non-linear inertia-variant multi-body systems. This leads to two different representations of inertia nonlinearities; one is based on a consistent mass formulation, while the other is a lumped mass technique. The multi-body systems considered are collections of interconnected rigid and flexible bodies. Open and closed loop systems are permitted. Author

A85-37448
OPTIMIZATION OF STRUCTURES WITH MULTIPLE FREQUENCY CONSTRAINTS
N. S. KHOT (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) Computers and Structures (ISSN 0045-7949), vol. 20, no. 5, 1985, p. 869-876. refs

The problem of designing a structures with multiple frequency constraints by using an optimality criterion method was investigated. The frequency constraints include the condition that the frequencies are equal or separated by a specified interval with a preselected vibration mode associated with the fundamental frequency. Three different scaling procedures are discussed to make the fundamental or any other frequency equal to the desired value. A 38 member truss structure with different constraint conditions and two distribution of nonstructural masses was optimized. Author

A85-37814
THE MILITARY SPACE SYSTEM TECHNOLOGY PLAN - A GUIDANCE, NAVIGATION AND CONTROL PERSPECTIVE FROM TECHNOLOGY WORKSHOP III
E. J. PELKA, R. AGLER, K. DALY, R. QUARTARARO, J. SESAK, R. SOLT, J. VELMAN, I. J. WILLIAMS, R. K. WILLIAMSON, and J. M. WALDMAN (Aerospace Corp., El Segundo, CA) IN: PLANS '84 - Position Location and Navigation Symposium, San Diego, CA, November 26-29, 1984, Record . New York, Institute of Electrical and Electronics Engineers, Inc., 1984, p. 128-135.

The Military Space System Technology Plan (MSSTP) is a systematic approach to identifying future space-related technology needs based on perceived mission requirements. The plan presents a broad scope of information pertaining to projected military space missions, systems, and technology requirements for the next 20 years. The AIAA was asked by Space Division to review this plan and to provide an industry view of the MSSTP. The activity was divided into 17 different functional areas representing a broad spectrum of supporting technologies. This report covers only the Guidance, Navigation and Control (GN&C) technology panel results. The Technology review topics were primarily oriented toward GN&C functions spanning many missions such as: flight computers, software development and verification; survivability; long life; acquisition, pointing and tracking; large space structure control; and GN&C sensors. This paper presents a summary of the GN&C results achieved in the Workshop activity. Author

A85-37815* Jet Propulsion Lab., California Inst. of Tech., Pasadena.
FUTURE PAYLOAD ISOLATION AND POINTING SYSTEM TECHNOLOGY
R. A. LASKIN and S. W. SIRLIN (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, CA) IN: PLANS '84 - Position Location and Navigation Symposium, San Diego, CA, November 26-29, 1984, Record . New York, Institute of Electrical and Electronics Engineers, Inc., 1984, p. 136-146. NASA-supported research. refs

Pointing requirements for spaceborne scientific instruments are getting progressively more stringent. At the same time the instruments are likely to fly in an increasingly disturbance rich environment characterized by large basebody and instrument to instrument dynamic interactions. It is not clear that current state-of-the-art pointing technology will be able to adequately address the needs of the mid 1990's. Design options to meet these needs are suggested herein including an innovative 'softmount' concept. The advantages of the softmount approach as compared to the traditional gimbal architecture are illustrated through a planar stability and disturbance response analysis.
Author

A85-38356#
IMPROVEMENT ON THE STABILIZATION OF A PRECISION TRACKING SYSTEM
H. KUNO and T. KOSHIBA Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 32, no. 360, 1984, p. 52-59. In Japanese, with abstract in English.

A tracking system that operates from nonstationary platforms must be able to stabilize the tracking axis for precision tracking. Implementation of a free gyro pointing assembly which has a momentum wheel as an integral part of the inner gimbal assembly and that is oriented with its spin axis parallel to the line of sight, is the most widely used method for tactical missiles. The paper describes two methods to improve the stabilization of this tracking system by adjusting the gimbal balance during accelerated condition and adjusting gimbal friction torque at an optimium level appropriate to the applied torque. The results show a one-fifth improvement of the drift rate.
Author

A85-38923
HIGHER-ORDER UPDATES FOR DYNAMIC RESPONSES IN STRUCTURAL OPTIMIZATION
A. H. JAWED and A. J. MORRIS (Cranfield Institute of Technology, Cranfield, Beds., England) Computer Methods in Applied Mechanics and Engineering (ISSN 0045-7825), vol. 49, June 1985, p. 175-201. refs

Problems of structural re-analyses in design optimization with constraints on the vibration response of dynamically loaded structures have been addressed. The inherent nonlinearity of the response quantities with respect to the design variables has in the past limited the application to first-order natural frequency updates. Second-order methods have tended to be prohibitive because of the need to evaluate the natural modes (eigenvectors) updates. The method proposed adopts an alternate and more direct approach to the forced vibration problems by evaluating the nodal response updates in a given direction. The update formulation developed takes advantage of the mutual orthogonality of the natural modes to construct higher-order directional derivatives of the transformed coordinate (modal) response quantities. These are subsequently used to obtain a total summation of the Taylor series representation for the response updates. The formulation is particularly suited to the design of large structures where modal truncation can be employed to restrict the computational costs. Numerical examples have been provided to illustrate both the higher quality and the effects of modal truncation on the results.
Author

A85-39272
STRUCTURAL DYNAMICS TESTING AND ANALYSIS; PROCEEDINGS OF THE AEROSPACE CONGRESS AND EXPOSITION, LONG BEACH, CA, OCTOBER 15-18, 1984
Congress and Exposition sponsored by the Society of Automotive Engineers. Warrendale, PA, Society of Automotive Engineers, Inc. (SAE SP-596), 1984, 101 p. For individual items see A85-39273 to A85-39282.
(SAE SP-596)

A time-domain method for establishing modal parameters and flutter margins from Space Shuttle flight data is discussed along with the efficiencies of multiple-input techniques for aircraft ground vibration testing, forced structural response using component mode synthesis, and a design parametric study of weapon systems utilizing computer aided engineering. Attention is given to a discussion of modal test techniques as applied to a spacecraft structure, uncertainty management in modeling and control of large flexible structures, and practical considerations in modal transient response analysis and response spectrum superposition. Other topics explored are related to the principles of vibration screening of deliverable equipment, a probabilistic approach in spacecraft solar array deployment analysis, and aspects of dynamic model verification of a multicomponent system.
G.R.

A85-39278
UNCERTAINTY MANAGEMENT IN MODELING AND CONTROL OF LARGE FLEXIBLE STRUCTURES
H. V. PANOSSIAN (HR Textron, Inc., Valencia, CA) IN: Structural dynamics testing and analysis; Proceedings of the Aerospace Congress and Exposition, Long Beach, CA, October 15-18, 1984 . Warrendale, PA, Society of Automotive Engineers, Inc., 1984, p. 55-58.
(SAE PAPER 841580)

A formal procedure for generating a stochastic model for flexible structures is presented herein. The 'best' available analytical model is taken and modeling errors and other random uncertainties are incorporated in the given model to generate a stohastic model. The optimal stochastic control for the system is derived and its performance is compared both with the deterministic model using a deterministic controller and with the stochastic model using the deterministic controller. A specific example is simulated whereby the results are plotted for different cases. Comments regarding applicability of the procedures are included.
Author

A85-39555#
ROLL/YAW CONTROL OF A FLEXIBLE SPACECRAFT USING SKEWED BIAS MOMENTUM WHEELS
B. WIE, J. A. LEHNER, and C. T. PLESCIA (Ford Aerospace and Communications Corp., Systems Analysis Dept., Palo Alto, CA) (Guidance and Control Conference, Seattle, WA, August 20-22, 1984, Technical Papers, p. 666-673) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 8, July-Aug. 1985, p. 447-453. Previously cited in issue 21, p. 3009, Accession no. A84-43474. refs

A85-39556#
SPACE STRUCTURE CONTROL DESIGN BY VARIANCE ASSIGNMENT
R. E. SKELTON (Purdue University, West Lafayette, IN) and M. DELORENZO (U.S. Air Force Academy, Colorado Springs, CO) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 8, July-Aug. 1985, p. 454-462. refs
(Contract AF-AFOSR-82-0209; NSF ECS-81-19598)

Algorithms designed to assign specified root-mean-squared values to multiple inputs or multiple outputs are constructed. The algorithms are used to select sensors and actuators from an admissible set of types and locations, and to determine actuator design requirements for the control of flexible structures to meet specified output variance constraints. Numerical properties of the convergence of the algorithms are demonstrated for NASA's 64-m hoop-column antenna.
M.D.

A85-39557#
IDENTIFICATION OF VIBRATING FLEXIBLE STRUCTURES
S. RAJARAM (Ithaco, Inc., Ithaca, NY; Virginia Polytechnic Institute and State University, Blacksburg, VA) and J. L. JUNKINS (Virginia Polytechnic Institute and State University, Blacksburg, VA) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 8, July-Aug. 1985, p. 463-470. Previously cited in issue 20, p. 2899, Accession no. A84-41367. refs
(Contract F4920-83-K-0032)

A85-39568#
AN ANALYTICAL APPROACH TO GEOSYNCHRONOUS STATION ACQUISITION
C. F. GARTRELL (General Research Corp., McLean, VA) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 8, July-Aug. 1985, p. 535-537. refs

An analytical technique for geosynchronous station acquisition which permits the estimation of an optimal maneuver sequence without enlisting the aid of massive computer software systems is discussed. It is shown that the technique minimizes the deviation between a finite burn approximation and the exact solution to the problem of station acquisition and that to make a fixed longitude change the solution uses the minimum velocity change and minimum number of maneuvers. An example of the maneuver design is given. M.D.

A85-40547* *Massachusetts Inst. of Tech., Cambridge.*
DISTURBANCE-ACCOMMODATING TRACKING MANEUVERS OF FLEXIBLE SPACECRAFT
J. D. TURNER (Charles Stark Draper Laboratory, Inc., Cambridge, MA), J.-N. JUANG (NASA, Langley Research Center, Hampton, VA), and H. M. CHUN (Southeastern Conference on Theoretical and Applied Mechanics, 12th, Pine Mountain, GA, May 11, 1984) Journal of the Astronautical Sciences (ISSN 0021-9142), vol. 33, Apr.-June 1985, p. 147-161. refs
(Contract F04701-79-C-0083)

In this paper the problem of maneuvering a flexible spacecraft through a large angle is considered, where the disturbance-accommodating feedback control tracks a desired output state. The desired output state is provided from an open-loop solution for the linear system model. The components of the disturbance vector are assumed to be represented in terms of Fourier series. Closed-form solutions are provided for the Ricati, prefilter, state trajectory, and residual state trajectory equations which define the optimal control. Example maneuvers are presented where control-rate penalties have been included in the performance index for frequency-shaping, in order to smooth both the open- and closed-loop control commands. Author

A85-40548* Colorado State Univ., Fort Collins.
EXACT SPACECRAFT DETUMBLING AND REORIENTATION MANEUVERS WITH GIMBALED THRUSTERS AND REACTION WHEELS
T. A. W. DWYER, III (Colorado State University, Fort Collins) and A. L. BATTEN (U.S. Air Force Academy, Colorado Springs, CO) Journal of the Astronautical Sciences (ISSN 0021-9142), vol. 33, Apr.-June 1985, p. 217-232. refs
(Contract NSF ECS-83-04968; NAG1-436; F4920-83-K-0032)

The equations of rotational motion for a spacecraft equipped with external jets and internal reaction wheels are shown to be feedback-equivalent to those of a linear system in attitude parameter space. Reorientation maneuvers are thereby formulated as linear optimal control problems with least mean square acceleration in attitude parameter space, solved in closed form and implementable either with internal or external torque commands, the choice depending on power and throttling requirements. For prior detumbling, an alternative solution with least mean square torque by angular momentum feedback is also given, that is implementable with gimbaled pairs of thrusters at constant throttle. Such a detumbling maneuver may then be followed by an acceleration-commanded rest-to-rest maneuver by means of the reaction wheels. Author

A85-40983#
DYNAMIC MODELLING OF FLEXIBLE SPACECRAFT-HYBRID SYSTEM AND TRUNCATION
Y. OHKAMI and H. FUJII Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 32, no. 364, 1984, p. 263-274. In Japanese. refs

Recent developments in hybrid coordinate systems and truncation are discussed. Emphasis is given to dynamic modelling of flexible spacecraft for designing and analyzing its altitude control system. Modelling methods for deriving a control system from a hybrid system, such as appendage- and vehicle-mode methods, are mathematically analyzed. Appendageand vehicle-mode methods are compared on the basis of eigenvalues and Green function. Truncation criteria based on mode frequency and modal identities is characterized. S.H.

A85-41120
MODELING STRUCTURES FOR CONTROL DESIGN
R E. SKELTON and A. HU (Purdue University, West Lafayette, IN) (George Washington University and NASA, Symposium on Advances and Trends in Structures and Dynamics, Washington, DC, Oct. 22-25, 1984) Computers and Structures (ISSN 0045-7949), vol. 20, no. 1-3, 1985, p. 303-309. refs

A simply supported beam is used as an example to illustrate the need for more theoretical research on the unification of the modeling and control problems of flexible structures. This paper shows that finite element methods that focus on the convergence of modal data may not be the best approach to modeling structures for control design. This is due primarily to the fact that (1) the importance of a mode in the control problem is measured by its modal costs, and modal cost errors may exceed (by large margins) the errors in modal frequency; (2) the modal costs are not ordered by frequency; and (3) convergence of the modal costs is not monotonic with the number of uniform finite elements. Hence, nonuniform finite element grids may be more efficient. Theorems for convergence of the modal costs are also presented. Author

A85-41135
DAMPING SYNTHESIS AND DAMPED DESIGN FOR FLEXIBLE SPACECRAFT STRUCTURES
M. L. SONI, M. F. KLUESENER, and M. L. DRAKE (Dayton, University, OH) (George Washington University and NASA, Symposium on Advances and Trends in Structures and Dynamics, Washington, DC, Oct. 22-25, 1984) Computers and Structures (ISSN 0045-7949), vol. 20, no. 1-3, 1985, p. 563-574. Research supported by International Telecommunication Satellite, Inc. refs

This paper concerns the prediction and enhancement of damping of flexible spacecraft structures. Methods of damping synthesis are briefly reviewed and an improved synthesis method is developed. Two example problems are given illustrating the validity of the damping synthesis. The results of several passive designs developed and evaluated on a representative flexible appendage are discussed. Author

A85-41137
CONTINUUM PLATE FINITE ELEMENTS FOR VIBRATION ANALYSIS AND FEEDBACK CONTROL OF SPACE LATTICE STRUCTURES
S. E. LAMBERSON (USAF, Washington, DC) and T. Y. YANG (Purdue University, West Lafayette, IN) (George Washington University and NASA, Symposium on Advances and Trends in Structures and Dynamics, Washington, DC, Oct. 22-25, 1984) Computers and Structures (ISSN 0045-7949), vol. 20, no. 1-3, 1985, p. 583-592. refs
(Contract AF-AFOSR-83-0104)

A variety of research projects are being pursued involving the dynamics and control of large space platforms made up of lattice-type truss structures. A method involving finite element modeling of an equivalent continuum formulation based on matching the strain energy and kinetic energy is developed. The method is shown to give modal results consistent with those obtained using detailed finite element modeling of the space lattice structure, even for structures with fairly small numbers of repetitions

of an identical unit cell. Feedback controllers designed using reduced system models derived from these modal results using Modal Cost Analysis are shown to perform as well as controllers designed using the detailed analysis results. Author

A85-41680
SYNTHESIS OF A DYNAMIC REGULATOR IN THE CASE OF AN ARTIFICIAL INTERRELATIONSHIP OF THE MOTIONS OF A SPACECRAFT AND ELASTIC SOLAR PANELS [SINTEZ DINAMICHESKOGO REGULIATORA PRI ISKUSSTVENNOI VZAIMOSVIAZI DVIZHENII KOSMICHESKOGO APPARATA S UPRUGIMI PANELIAMI SOLNECHNYKH BATAREI]
V. A. TKACHENKO Kosmicheskie Issledovaniia (ISSN 0023-4206), vol. 23, May-June 1985, p. 358-370. In Russian. refs

It is shown that the order of a dynamic regulator providing for a prescribed spectrum of a closed control system can be reduced significantly by means of an artificial interrelationship of motions effected by the regulator. These results are extended to an arbitrary number of initial independent dynamic systems of arbitrary form under the condition that they are observable and controllable. The interrelated motions of a spacecraft and solar panels are considered as an example. B.J.

A85-41864
A PRELIMINARY STUDY ON DECENTRALIZED CONTROL OF LARGE-SCALE FLEXIBLE SPS
T. KIDA and Y. OHKAMI (National Aerospace Laboratory, Chofu, Japan) (University of Tokyo and Ministry of Education, Science, and Culture, Space Energy Symposium, 3rd, Tokyo, Japan, Mar. 26, 1984) Space Solar Power Review (ISSN 0191-9067), vol. 5, no. 2, 1985, p. 171-177.

This preliminary study is intended to investigate the possibility of applying the local decentralized feedback control technique to the SPS attitude/shape control. The controller is implemented by feeding back only the local measurements, and its feedback gains are designed based on the small-size subsystem model. The analyses performed in this paper are concentrated to (1) the total SPS system stability evaluation and (2) the convergence speed estimation, based on the information of an aggregate model. A simple numerical model is introduced to illustrate the design procedure and the stability evaluation results. It is concluded that the major problems of the SPS mission can be attained by the proposed local decentralized control. Author

A85-42371*# Virginia Polytechnic Inst. and State Univ., Blacksburg.
ENHANCED VIBRATION CONTROLLABILITY BY MINOR STRUCTURAL MODIFICATIONS
R. T. HAFTKA, W. L. HALLAUER, JR., and Z. N. MARTINOVIC (Virginia Polytechnic Institute and State University, Blacksburg) (Structures, Structural Dynamics and Materials Conference, 25th, Palm Springs, CA, May 14-16, 1984, and AIAA Dynamics Specialists Conference, Palm Springs, CA, May 17, 18, 1984, Technical Papers. Part 2, p. 401-410) AIAA Journal (ISSN 0001-1452), vol. 23, Aug. 1985, p. 1260-1266. Previously cited in issue 13, p. 1915, Accession no. A84-31728. refs
(Contract NAG1-224; NSF CME-80-14059)

A85-42919*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
TIME-DOMAIN RESPONSE ENVELOPE FOR STRUCTURAL DYNAMIC SYSTEMS
J.-C. CHEN, M. TRUBERT, and J. A. GARBA (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) (Structures, Structural Dynamics and Materials Conference, 24th, Lake Tahoe, NV, May 2-4, 1983, Collection of Technical Papers. Part 2, p. 82-91) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 22, July-Aug. 1985, p. 442-449. Previously cited in issue 12, p. 1707, Accession no. A83-29817. refs
(Contract NAS7-100)

A85-44269
APPLICATION OF A METHOD FOR IDENTIFYING INCOMPLETE SYSTEM MATRICES USING VIBRATION TEST DATA
M. LINK (Kassel, Gesamthochschule, West Germany) Zeitschrift fuer Flugwissenschaften und Weltraumforschung (ISSN 0342-068X), vol. 9, May-June 1985, p. 178-187.
(Contract ESA-5597/83/NL/PB(SC))

It is pointed out that the objective of identifying the physical mass, stiffness, and damping matrices of large structures with several hundreds of degrees of freedom for the related mathematical model may be too ambitious because of the involved practical vibration and modal survey test conditions. Under real test conditions, the complete information required is not available, and any physical system matrix identification can only be based on incomplete model matrices. Link (1985) has discussed a procedure for the identification of incomplete system matrices. The considered procedure has been implemented in a computer software package, called ISSPA, which includes also the preprocessing of dynamic test data and the postprocessing of the identified data. Scholz (1984) has employed a vibration system with five degrees of freedom to test the sensitivity and accuracy of the identification procedure. Attention is also given to an application of ISSPA to test data in the case of a satellite antenna structure. G.R.

A85-44740* Anamet Labs., Inc., San Carlos, Calif.
APPLICATION OF RITZ VECTORS FOR DYNAMIC ANALYSIS OF LARGE STRUCTURES
R. R. ARNOLD, R. L. CITERLEY (Anamet Laboratories, Inc., San Carlos, CA), M. CHARGIN, and D. GALANT (NASA, Ames Research Center, Moffett Field, CA) Computers and Structures (ISSN 0045-7949), vol. 21, no. 3, 1985, p. 461-467. refs

The use of an orthogonal set of specially selected Ritz vectors is shown to be very effective in reducing the cost of dynamic analysis by modal superposition. Several mechanical structures are examined, and the Ritz vector approach is compared to the classical eigenvector approach on the basis of cost, accuracy and elapsed analysis (throughput) time. Mathematical proof of the completeness of orthogonal Ritz vectors is provided for the case of a positive definite mass matrix and a symmetric stiffness matrix. Author

A85-45876
GUIDANCE, NAVIGATION AND CONTROL CONFERENCE, SNOWMASS, CO, AUGUST 19-21, 1985, TECHNICAL PAPERS
Conference sponsored by AIAA. New York, AIAA, 1985, 849 p. For individual items see A85-45877 to A85-45968.

The papers presented in this volume provide an overview of recent theoretical and experimental research in the field of guidance, navigation, and control. Topics discussed include flying qualities in the time domain, space telescope moving target tracking, the role of robotics in space system operations, and the use of expert systems for adaptive control of large space structures. Papers are also presented on linear guidance laws for space missions, improved feedback algorithms for optimal maneuvers in vertical plane, wheel configurations for combined energy storage and attitude control systems, and application of adaptive control to space stations. V.L.

A85-45886#
MASS PROPERTY ESTIMATION FOR CONTROL OF ASYMMETRICAL SATELLITES
E. V. BERGMANN (Charles Stark Draper Laboratory, Inc., Cambridge, MA), B. K. WALKER (MIT, Cambridge, MA), and D. R. LEVY (USAF, Washington, DC) IN: Guidance, Navigation and Control Conference, Snowmass, CO, August 19-21, 1985, Technical Papers . New York, AIAA, 1985, p. 83-93. Research supported by the Charles Stark Draper Laboratory, Inc. refs
(AIAA PAPER 85-1857)

Real-time algorithms that estimate the mass-property parameters commonly used in spacecraft control laws are developed based upon a stochastic estimation viewpoint. The elements of the inverse inertia matrix and the center-of-mass

location vector are estimated from noisy measurements of the angular velocity using a second-order filter, while estimates of the mass reciprocal are generated from noisy linear velocity measurements using a Kalman filter. Simulation results show that the rate of convergence of each estimate depends strongly upon the particular maneuver being performed, but that the mass properties can be estimated to within one percent error. Author

A85-45893#
ATTITUDE DYNAMICS OF SPACECRAFT WITH CONTROLLED FLEXIBLE APPENDAGE AND ETS-III ON-ORBIT PERFORMANCE
T. KAWASHIMA, J. SHIMIZU (National Space Development Agency of Japan, Tokyo), M. SHIGEHARA, and S. TSUDA (Toshiba Corp., Kawasaki, Japan) IN: Guidance, Navigation and Control Conference, Snowmass, CO, August 19-21, 1985, Technical Papers . New York, AIAA, 1985, p. 144-151.
(AIAA PAPER 85-1864)

A general formulation has been developed for the attitude dynamics of a spacecraft with controlled flexible appendages. It is applicable to evaluate the dynamical effect of controlling the orientation and/or the position of flexible structural elements. To obtain a simple formulation, the flexible element is expressed only in the modal space coordinates with the synthetic mode approach. This eliminates a burden of matrix inverting operations in the computational procedure which is derived from the time-dependency of mass and stiffness spatial distributions. An application is also included for the investigation of Japanese ETS-III spacecraft on-orbit performance with unexpected attitude rate output. The investigation result shows the dynamical interaction with the solar array rotation and an on-orbit experiment to stop the rotation has been done to demonstrate it. Author

A85-45906#
ACTIVE MODAL CONTROL OF FLEXIBLE MANIPULATORS IN APPLICATION TO SPACE CONSTRUCTION AND SERVICING
J. S.-C. YUAN (Spar Aerospace, Ltd., Toronto, Canada) IN: Guidance, Navigation and Control Conference, Snowmass, CO, August 19-21, 1985, Technical Papers . New York, AIAA, 1985, p. 260-268. Sponsorship: Department of Supply and Services.
(Contract DSS-13SR-31053-3-3805Y)
(AIAA PAPER 85-1883)

The point stability of manipulators in the presence of external disturbances associated with space construction and servicing (SCS) is considered. Manipulator control strategies are compared on the basis of a two-dimensional model of an SCS manipulator. The control strategies studied were: rigid-body control; and a strategy including a selected number of flexural modes in the control design. The compensator in each case was a multivariable proportional-integral controller. It is shown that the active modal control is highly robust with respect to variations in the controller gain and the flexural stiffness of the manipulator. In particular, active modal control had a much shorter disturbance recovery time than rigid body control. I.H.

A85-45918#
THE USE OF EXPERT SYSTEMS FOR ADAPTIVE CONTROL OF LARGE SPACE STRUCTURES
C. F. GARTRELL, D. KOZARSKY (General Research Corp., McLean, VA), and R. M. HORD (MRJ, Inc., Oakton, VA) IN: Guidance, Navigation and Control Conference, Snowmass, CO, August 19-21, 1985, Technical Papers . New York, AIAA, 1985, p. 376-385. refs
(AIAA PAPER 85-1906)

It is expected that space systems for the future will evolve to structures of unprecedented size, with associated extreme control requirements. The current methods for active control of large space structures suffer from basic limitations: strong dependence upon high fidelity parameter estimates and the inability to recognize system performance changes. An alternative approach using artificial intelligence is postulated that may overcome these limits. A proof-of-concept investigation has shown the marked advantages of an expert system controller over numerical control for a simple object, providing an indication of the promise of expert systems in this application. Author

A85-45923#
EXPERIMENTAL-THEORETICAL STUDY OF ACTIVE DAMPING WITH DUAL SENSORS AND ACTUATORS
G. R. SKIDMORE and W. L. HALLAUER, JR. (Virginia Polytechnic Institute and State University, Blacksburg) IN: Guidance, Navigation and Control Conference, Snowmass, CO, August 19-21, 1985, Technical Papers . New York, AIAA, 1985, p. 433-442. refs
(Contract F49620-83-C-0158; F49620-85-C-0024; NSF CME-80-14059)
(AIAA PAPER 85-1921)

Active vibration damping was implemented on a pendulous, two-dimensional laboratory structure having 13 vibration modes with natural frequencies under 10 Hz and very light inherent damping. The control system includes a digital controller and five pairs of dual (colocated) velocity sensors and force actuators, which were supported externally, not borne by the vibrating structure. This control system was used for implementation of two different active damping techniques, uncoupled and coupled output rate feedback. The former was based on a minimum-gain criterion, the latter on modal-space active damping. Both techniques produced substantial active damping of eleven modes with natural frequencies under 10 Hz, and both positively augmented the damping of all modes. Good agreement was achieved between experimentally measured and theoretically calculated structure-control system dynamic response. Author

A85-45924#
EXPERIMENTAL COMPARISON OF WAVE-ABSORBING AND MODAL-BASED LOW-AUTHORITY CONTROLLERS FOR A FLEXIBLE BEAM
A. H. VON FLOTOW and B. SCHAEFER (DFVLR, Oberpfaffenhofen, West Germany) IN: Guidance, Navigation and Control Conference, Snowmass, CO, August 19-21, 1985, Technical Papers . New York, AIAA, 1985, p. 443-452. refs
(AIAA PAPER 85-1922)

This paper describes theoretical and experimental work performed on the modelling and vibration control of a hanging flexible beam. The particular beam, and the actuators and sensors used were developed at the DFVLR over the past three years in order to test various control algorithms in an idealized setting. The synthesis and laboratory implementation of low-authority controllers based upon feedback of structural deflection velocity to actuator force has been the subject of previous studies. This paper extends this previous work with the design and laboratory implementation of low-authority controllers based upon concepts of disturbance propagation and reflection. Control forces are applied to the lower end of the hanging beam. Compensators are derived which feed back local deflection and slope to control force and moment with the goal of minimizing the reflection of energy at the lower end. Several of these compensators are approximated by analog electronic filters for laboratory implementation. The performance of these wave-absorbing compensators is compared with that of velocity feedback.
Author

A85-45925#
ESTIMATION OF DISTRIBUTED PARAMETER SYSTEMS - SOME CLOSED FORM SOLUTIONS
D. B. SCHAECHTER (Lockheed Missiles and Space Co., Inc., Palo Alto, CA) IN: Guidance, Navigation and Control Conference, Snowmass, CO, August 19-21, 1985, Technical Papers . New York, AIAA, 1985, p. 453-458. Research supported by the Lockheed Independent Research and Development Program. refs
(AIAA PAPER 85-1923)

The estimation and control of distributed parameter systems has numerous applications in the control of structures. In many cases, obtaining the solutions of estimation and control problems which involve partial differential equations requires the use of numerical methods and yields only approximate answers. In this

paper, exact solutions are obtained for several practical estimation problems associated with static systems, solutions that cannot be obtained by any other reasonable approach. Author

A85-45926#
SIMULTANEUS OPTIMAL STRUCTURAL/CONTROL MODIFICATIONS TO ENHANCE THE VIBRATION CONTROL OF A LARGE FLEXIBLE STRUCTURE
N. S. KHOT, V. B. VENKAYYA (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH), and F. E. EASTEP (Dayton, University, OH) IN: Guidance, Navigation and Control Conference, Snowmass, CO, August 19-21, 1985, Technical Papers . New York, AIAA, 1985, p. 459-466. refs
(AIAA PAPER 85-1925)

A method is presented to design a minimum weight structure with contraints on the distribution of the eigenvalues and the damping parameters of a closed-loop system in the design of an active control system. The structural modifications, i.e., changes in the cross-sectional areas of the members, are achieved by using a nonlinear mathematical optimization technique. Application of the algorithm is illustrated by designing an ACOSS-FOUR model with different constraint values. Author

A85-45950#
ROBUST BEAM-POINTING AND ATTITUDE CONTROL OF A FLEXIBLE SPACECRAFT
J. S.-C. YUAN (Spar Aerospace, Ltd., Toronto, Canada) and M. E. STIEBER (Department of Communications, Communications Research Centre, Ottawa, Canada) IN: Guidance, Navigation and Control Conference, Snowmass, CO, August 19-21, 1985, Technical Papers . New York, AIAA, 1985, p. 688-695. Research supported by the Department of Communications. refs
(AIAA PAPER 85-1967)

This paper studies the problem of simultaneously controlling the communications beam and the attitude angles of the main bus of a flexible spacecraft. The controller is a multivariable proportional-integral compensator augmented by a Kalman filter. Two design methods have been explored: the first method is based on eigenvalue analysis, while the second makes use of a singular value criterion. Both approaches result in a controller that is robust in the presence of the residual modes omitted from the design model. The singular value method, however, is shown to be far more conservative than the eigenvalue method. Author

A85-45951#
PRELIMINARY EVALUATION OF AN ATTITUDE CONTROL SYSTEM FOR THE SPACE STATION
H. H. WOO and J. D. ALMANZA (Rockwell International Corp., Downey, CA) IN: Guidance, Navigation and Control Conference, Snowmass, CO, August 19-21, 1985, Technical Papers . New York, AIAA, 1985, p. 696-708. refs
(AIAA PAPER 85-1968)

Preliminary results are given from simulation studies of the projected NASA Space Station's Attitude Control System design requirements and achievable controllability, on the basis of classical control design techniques. Evaluations are made of assembly, steady state, and transition operations, in terms of mission, operational, and functional requirements; simulation methods for the large angle rotation of flexible appendages, evolving geometry, and moving bodies, are developed. Attention is given to a momentum management concept emphasizing minimum interference with experiments in progress in the station. O.C.

A85-45952*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
APPLICATION OF ADAPTIVE CONTROL TO SPACE STATIONS
C.-H. C. IH, S. J. WANG (California Institute of Technology, Jet Propulsion Laboratory, Pasadena), and C. T. LEONDES (California, University, Los Angeles) IN: Guidance, Navigation and Control Conference, Snowmass, CO, August 19-21, 1985, Technical Papers . New York, AIAA, 1985, p. 709-724. NASA-supported research. refs
(AIAA PAPER 85-1970)

The space station will be deployed and assembled in low earth orbit with multiple Shuttle trips. Several construction phases will be required involving both ground and in-orbit operations. In this paper, the construction process of a four-panel space station and its control problems are discussed. The applicability of a direct model reference adaptive control technique with plant augmentation is investigated. Control during several key assembly operation periods has been simulated. These include Shuttle docking with initial-phase station, habitat module mating, and Shuttle docking with operational station. High rate of convergence and robust performance have been observed for all the simulated cases even with 40 percent model parameter errors and model truncations and more than 100 percent instant mass property variations. Controller with severe gain saturations is also discussed and results show only slight performance deterioration. Author

A85-45953*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
A SEQUENTIAL LINEAR OPTIMIZATION APPROACH FOR CONTROLLER DESIGN
L. G. HORTA, J.-N. JUANG (NASA, Langley Research Center, Hampton, VA), and J. L. JUNKINS (Virginia Polytechnic Institute, Blacksburg) IN: Guidance, Navigation and Control Conference, Snowmass, CO, August 19-21, 1985, Technical Papers . New York, AIAA, 1985, p. 725-731. refs
(AIAA PAPER 85-1971)

A linear optimization approach with a simple real arithmetic algorithm is presented for reliable controller design and vibration suppression of flexible structures. Using first order sensitivity of the system eigenvalues with respect to the design parameters in conjunction with a continuation procedure, the method converts a nonlinear optimization problem into a maximization problem with linear inequality constraints. The method of linear programming is then applied to solve the converted linear optimization problem. The general efficiency of the linear programming approach allows the method to handle structural optimization problems with a large number of inequality constraints on the design vector. The method is demonstrated using a truss beam finite element model for the optimal sizing and placement of active/passive-structural members for damping augmentation. Results using both the sequential linear optimization approach and nonlinear optimization are presented and compared. The insensitivity to initial conditions of the linear optimization approach is also demonstrated. Author

A85-46332*# Honeywell, Inc., Clearwater, Fla.
DYNAMICS OF FLEXIBLE BODIES IN TREE TOPOLOGY - A COMPUTER-ORIENTED APPROACH
R. P. SINGH, R. J. VANDERVOORT (Honeywell, Inc., Clearwater, FL), and P. W. LIKINS (Lehigh University, Bethlehem, PA) (Structures, Structural Dynamics and Materials Conference, 25th, Palm Springs, CA, May 14-16, 1984, and AIAA Dynamics Specialists Conference, Palm Springs, CA, May 17, 18, 1984, Technical Papers. Part 2, p. 327-337) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 8, Sept.-Oct. 1985, p. 584-590. NASA-sponsored research. Previously cited in issue 13, p. 1915, Accession no. A84-31719. refs

A85-46333*# Howard Univ., Washington, D. C.
DYNAMICS AND CONTROL OF ORBITING FLEXIBLE STRUCTURES EXPOSED TO SOLAR RADIATION
R. KRISHNA and P. M. BAINUM (Howard University, Washington, DC) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 8, Sept.-Oct. 1985, p. 591-596. Previously cited in issue 20, p. 2861, Accession no. A84-41364. refs
(Contract NSG-1414)

A85-46334#
EXPERIMENTAL RESEARCH ON FLEXIBLE BEAM MODAL CONTROL
B. E. SCHAEFER and H. HOLZACH (DFVLR, Oberpfaffenhofen, West Germany) (Structures, Structural Dynamics and Materials Conference, 25th, Palm Springs, CA, May 14-16, 1984, and AIAA Dynamics Specialists Conference, Palm Springs, CA, May 17, 18, 1984, Technical Papers. Part 2, p. 317-326) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 8, Sept.-Oct. 1985, p. 597-604. Previously cited in issue 13, p. 1956, Accession no. A84-31718. refs

A85-46335#
DISTRIBUTED PIEZOELECTRIC-POLYMER ACTIVE VIBRATION CONTROL OF A CANTILEVER BEAM
T. BAILEY and J. E. HUBBARD, JR. (MIT, Cambridge, MA) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 8, Sept.-Oct. 1985, p. 605-611. Research supported by the Charles Stark Draper Laboratory, Inc. refs

It is pointed out that satellites and other large spacecraft structures are generally lightly damped due to low structural damping in the materials used. In large structures, these vibrations have long decay times which can lead to fatigue, instability, or other problems with the operation of the structure. The present investigation has the objective to design and experimentally evaluate an active vibration damper for distributed-parameter systems using a distributed-parameter actuator. The design and analysis of an active damper for a thin cantilever beam are discussed, and a description is provided of the apparatus and procedures used in the preliminary testing of the damper. G.R.

A85-46336#
DYNAMICS AND CONTROL OF LATTICE BEAMS USING SIMPLIFIED FINITE ELEMENT MODELS
D. T. BERRY, T. Y. YANG, and R. E. SKELTON (Purdue University, West Lafayette, IN) (Structures, Structural Dynamics and Materials Conference, 25th, Palm Springs, CA, May 14-16, 1984, and AIAA Dynamics Specialists Conference, Palm Springs, CA, May 17, 18, 1984, Technical Papers. Part 2, p. 422-430) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 8, Sept.-Oct. 1985, p. 612-619. Previously cited in issue 13, p. 1915, Accession no. A84-31730. refs
(Contract AF-AFOSR-83-0104)

A85-46337*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
AN EIGENSYSTEM REALIZATION ALGORITHM FOR MODAL PARAMETER IDENTIFICATION AND MODEL REDUCTION
J.-N. JUANG and R. S. PAPPA (NASA, Langley Research Center, Hampton, VA) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 8, Sept.-Oct. 1985, p. 620-627. refs

A method called the eigensystem realization algorithm is developed for modal parameter identification and model reduction of dynamic systems from test data. A new approach is introduced in conjunction with the singular-value decomposition technique to derive the basic formulation of minimum order realization which is an extended version of the Ho-Kalman algorithm. The basic formulation is then transformed into modal space for modal parameter identification. Two accuracy indicators are developed to quantitatively identify the system and noise modes. For illustration of the algorithm, an example is shown using experimental data from the Galileo spacecraft. Author

A85-46338#
CHARACTERISTIC ELASTIC SYSTEMS OF TIME-LIMITED OPTIMAL MANEUVERS
A. L. HALE and R. J. LISOWSKI (Illinois, University, Urbana) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 8, Sept.-Oct. 1985, p. 628-636. refs

In a spacecraft structure which is very flexible, the active control system can excite elastic deformations. Thus, the problem arises to achieve an optimum balance between the design of a flexible structure and the energy required for the active control of this structure. The present study represents a continuation of a number of investigations which address the problem of the so-called 'integrated optimization' of a structure and its active control. It is attempted to minimize the control energy required for a maneuver. Attention is given to the minimization of control cost, the minimization of the ratio of actual control cost to rigid-body control cost, a simple two-degree-of-freedom example, and a single-axis rotational maneuver of a symmetric four-boom structure. G.R.

A85-47038#
PIEZOELECTRIC DAMPING FOR SPACE STRUCTURES
R. DEMEIS Aerospace America (ISSN 0740-722X), vol. 23, Sept. 1985, p. 32, 33.

Uncontrolled vibrations are known to have damaged satellite structures. Piezoelectric film, composed of polarized polyvinylidene fluoride (PVF2), covered by a layer of Ni or Al was devised to control vibrations. In the test, a 0.011 in. thick film was bonded to one side of a steel hacksaw-like beam (the PVF2 was polarized along a single axis parallel to the length of the beam). A voltage applied in step with vibrations and determined by the angular velocity of the beam tip produces a strain in the film, damping the vibrations. The film was most effective in damping small displacements and in preventing weak vibrations at resonant frequencies from building up. Discrete actuators could handle the larger vibrations down to where piezoelectric damping is more effective. I.S.

A85-47676
1984 AMERICAN CONTROL CONFERENCE, SAN DIEGO, CA, JUNE 6-8, 1984, PROCEEDINGS. VOLUMES 1, 2 & 3
Conference sponsored by the American Automatic Control Council. New York, IEEE, 1984, Vol. 1, 623 p.; vol. 2, 628 p.; vol. 3, 772 p. For individual items see A85-47677 to A85-47803.

The topics considered are related to the modeling of human cognitive decision processes, sensor-based robot control systems, adaptive control and applications, modelling and simulation of thermofluid processes and systems, advanced concepts for computer-aided control system design, model reduction and large scale systems, fuel-optimal aircraft guidance and control, and digital signal processing. Other subjects explored are concerned with the dynamical systems approach to problems in nonlinear systems and control, monitoring and fault detection in power systems, robot path planning and control, the real time control of processes, pole placement design, large scale systems and model reduction, and aircraft control. Attention is also given to servomechanisms and machine tool control, stochastic systems, process model-based control and analysis, applications of multivalued logic, microprocessor implementation of real time control systems using high order languages, multitarget tracking, digital systems, filtering and estimation, optimal control, and fault tolerant aerospace systems. G.R.

A85-47682
SINGULAR VALUE ANALYSIS, BALANCING, AND MODEL REDUCTION OF LARGE SPACE STRUCTURES
E. A. JONCKHEERE and PH. OPDENACKER (Southern California, University, Los Angeles) IN: 1984 American Control Conference, San Diego, CA, June 6-8, 1984, Proceedings. Volume 1 . New York, IEEE, 1984, p. 141-149. refs
(Contract NSF ECS-82-12479)

The present paper is concerned with 'flexible systems'. 'Flexible systems' are defined as systems which can be characterized by transfer matrices, G(s), of a certain form. G(s) represents the

transfer matrix from a certain effort (force or torque) to a certain displacement (linear or angular). Another transfer matrix considered represents the transfer matrix from the effort to the displacement rate. Attention is given to singular value analysis, open and closed loop balancings, and open and closed loop approximations of transfer matrices G(s) of the considered form. The transfer matrices consist of many eigenmodes, and a certain 'measure of importance' is assigned to each mode. G.R.

A85-47715* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
IDENTIFICATION OF THE DYNAMICS OF A TWO-DIMENSIONAL GRID STRUCTURE USING LEAST SQUARE LATTICE FILTERS
R. C. MONTGOMERY and N. SUNDARARAJAN (NASA, Langley Research Center, Hampton, VA) IN: 1984 American Control Conference, San Diego, CA, June 6-8, 1984, Proceedings. Volume 2 . New York, IEEE, 1984, p. 704-709. refs

It is doubtful whether the dynamics of large space structures (LSS) can be predicted well enough for control system design applications. Hence, dynamic modeling from on-orbit measurements followed by a modification of the control system is of interest, taking into account the utilization of adaptive control concepts. The present paper is concerned with the model determination phase of the adaptive control problem. Using spectral decoupling to determine mode shapes, mode frequency and damping data can be obtained with the aid of an equation error parameter identification method. This method employs a second-order auto-regressive moving average (ARMA) model to represent the natural mode amplitudes. The discussed procedure involves an extension of the application of the least square lattice filter in system identification to a nonintegral, two-dimensional grid structure made of overlapping bars. G.R.

A85-47738
TIME DOMAIN ROBUSTNESS ANALYSIS FOR LINEAR REGULATORS
R. K. YEDAVALLI (Stevens Institute of Technology, Hoboken, NJ) IN: 1984 American Control Conference, San Diego, CA, June 6-8, 1984, Proceedings. Volume 2 . New York, IEEE, 1984, p. 975-980. refs

This paper addresses the aspect of robustness of linear regulators in time domain. First, a stability robustness condition in time domain (in terms of eigenvalues) is presented, and it is shown that the proposed robustness condition is less conservative than (1) the corresponding frequency domain condition and (2) another time domain condition recently proposed (in terms of singular values). Next a technique is presented to further reduce the conservatism of the proposed condition. Finally, a design algorithm that incorporates both stability robustness and performance robustness into the design procedure is suggested and simple examples are presented to illustrate the proposed concepts. Author

A85-47740* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
ESTIMATION OF REGIONS OF ATTRACTION AND ULTIMATE BOUNDEDNESS FOR MULTILOOP LQ REGULATORS
S. M. JOSHI (NASA, Langley Research Center, Hampton, VA) IN: 1984 American Control Conference, San Diego, CA, June 6-8, 1984, Proceedings. Volume 2 . New York, IEEE, 1984, p. 985-989.

Closed-loop stability is investigated for multivariable linear time-invariant systems controlled by optimal full state feedback linear quadratic (LQ) regulators, with nonlinear gains present in the feedback channels. Estimates are obtained for the region of attraction when the nonlinearities escape the (0.5, infinity) sector in regions away from the origin and for the region of ultimate boundedness when the nonlinearities escape the sector near the origin. The expressions for these regions also provide methods for selecting the performance function parameters in order to obtain LQ designs with better tolerance for nonlinearities. The analytical results are illustrated by applying them to the problem of controlling the rigid-body pitch angle and elastic motion of a large, flexible space antenna. C.D.

A85-47786
FEEDBACK CONTROL OF FLEXIBLE SPACECRAFT LARGE-ANGLE MANEUVERS USING LIAPUNOV THEORY
S. R. VADALI (Iowa State University of Science and Technology, Ames) IN: 1984 American Control Conference, San Diego, CA, June 6-8, 1984, Proceedings. Volume 3 . New York, IEEE, 1984, p. 1674-1678. refs

Feedback control laws are obtained for large-angle maneuvers of flexible spacecraft using Liapunov stability theory. The closed-loop distributed parameter system is shown to be stable. Simulation of the closed-loop system is performed by discretization using the assumed modes method. Author

A85-47787
REDUCED-ORDER MODELING APPLIED TO OPTIMAL DESIGN OF MANEUVERING FLEXIBLE STRUCTURES
A. L. HALE (Illinois, University, Urbana) and R. J. LISOWSKI IN: 1984 American Control Conference, San Diego, CA, June 6-8, 1984, Proceedings. Volume 3 . New York, IEEE, 1984, p. 1685-1690. refs

The theoretical implications of a reduced order structural model for integrated design of flexible structures are discussed. It is shown that the difference between the gradients of two different approximate and explicit reduced order problems is on the order of the inverse square of the lowest residual natural frequency of the inverse mode when lower eigenvectors are used in calculating the structural parameters. The issue of including derivatives of the trial vectors in calculations of the gradient of the cost functional is considered. The reduced-order model was applied to the analysis of the single axis rest-to-rest slewing maneuver of an idealized boom four-boom flexible structure. Optimal parameters for the structure were calculated numerically, and the results are given in a table. I.H.

A85-47793* Massachusetts Inst. of Tech., Cambridge.
CONTROL SYSTEM RECONFIGURATION
W. E. VANDER VELDE (MIT, Cambridge, MA) IN: 1984 American Control Conference, San Diego, CA, June 6-8, 1984, Proceedings. Volume 3 . New York, IEEE, 1984, p. 1741-1745.
(Contract NAG1-126)

The problem of reconfiguring a control system to accommodate the failure of a sensor or actuator is discussed in the context of several different system configurations. First, some ground rules under which the reconfiguration algorithms are to function are established. A variety of control system configurations is then considered, and it is found that the approach to reconfiguration is obvious in some cases but not clear in others. Several possible strategies for reconfiguration, applicable to different situations, are examined. V.L.

A85-48083
BLOCK-INDEPENDENT CONTROL OF DISTRIBUTED STRUCTURES
L. M. SILVERBERG and L. MEIROVITCH (Virginia Polytechnic Institute and State University, Blacksburg) Optimal Control Applications and Methods (ISSN 0143-2087), vol. 6, July-Sept. 1985, p. 281-289. refs
(Contract NSF PFR-80-20623)

As a compromise between coupled control and independent modal-space control, a block-independent control method is proposed. The computational difficulties encountered in coupled control are thereby reduced significantly. The requirement on the number of actuators is shown to be lower for block-independent control than for independent modal-space control, but only moderately so. A numerical example is presented. Author

A85-48876#
METHODS OF LARGE-SCALE SYSTEMS AND SATELLITE ATTITUDE DYNAMICS
Z.-L. WANG, S.-G. LIU, Y.-H. GUAN, and S.-T. HUANG (Qinghua University, Beijing, People's Republic of China) Chinese Journal of Space Science, vol. 3, April 1983, p. 81-102. In Chinese, with abstract in English. refs

This paper presents a method that can be applied to analysis of the stability of nonlinear unsteady mechanical systems, based on Chetaev's theory and the theory of large-scale systems: methods of large-scale systems with weighted V function. Moreover, this method is used for the research on the problems of attitude stability of a dual-spinning satellite, a large flexible spacecraft, and a satellite with cavity containing fluid. It can be seen that this method can be applied effectively to analyzing the stability of mechanical systems with constraint damping, gyrosystems, and the complex systems of spacecraft. Author

A85-49001
AEROSPACE SIMULATION; PROCEEDINGS OF THE CONFERENCE, SAN DIEGO, CA, FEBRUARY 2-4, 1984
M. UNG, ED. (Southern California, University, Los Angeles) La Jolla, CA, Society for Computer Simulation (Simulation Series, vol. 13, Feb. 1984), 1984, 229 p. For individual items see A85-49002 to A85-49021.

Among the topics discussed are the simulated flight ground testing of avionics systems, recent advancements in computer image generation, rotorcraft simulation systems at NASA's Ames facility, real time structural mode simulation, the Large Amplitude Multi-Mode Aerospace Research Simulator's application to the Advanced Fighter Technology Integration F-16, the dynamics and control simulation of large space structures, and real time models of flexible space structure dynamics. Also treated are the role of simulation in the development of the fuel-efficient B 757 and B 767 airliners, modeling techniques for transonic airfoils, the principles of optimal missile guidance and control system design, guidance and control simulations for laser-guided weapons, polarimetric radar simulation, and a code for dynamic gas turbine engine models. O.C.

A85-49009* Jet Propulsion Lab., California Inst. of Tech., Pasadena.
DYNAMICS AND CONTROL SIMULATION OF LARGE SPACE STRUCTURES
Y. H. LIN and J. CAMERON (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) IN: Aerospace simulation; Proceedings of the Conference, San Diego, CA, February 2-4, 1984 . La Jolla, CA, Society for Computer Simulation, 1984, p. 67-78. refs

Attention is given to the dynamics and control simulation techniques applicable to large space structures, encompassing the model of the large structure as well as models of its dynamics, its onboard controller, its sensor/actuator systems, and various disturbances to which it may be subjected. Control performance parameters must be computed as functions of time, or of such other design parameters as control gain. A large space antenna is used as an example of the structures in question, illustrating the way in which an efficient dynamics and control simulation structure program can be developed, and how antenna parameters such as reflector surface distortions can be computed, without having to solve a large number of equations for each computation time interval. O.C.

A85-49010
STOCHASTIC REALTIME MODELS FOR FLEXIBLE SPACE STRUCTURE DYNAMICS
W. KOHN IN: Aerospace simulation; Proceedings of the Conference, San Diego, CA, February 2-4, 1984 . La Jolla, CA, Society for Computer Simulation, 1984, p. 79-91. refs

In the present algorithm for the generation of space structure dynamic representations, the rigid dynamics undergoes perturbation by multidimensional elastic deformations that are distributed over some or all of the structure's elements. This generic model permits the representation of flexible-rigid dynamics' interactions as a diffusion process that is driven by a locally continuous martingale. The expectation-matching algorithm presented, which is a discretization scheme for this process, allows real time implementation and is based on the approximation of the stochastic dynamics of the diffusion process by way of a suitably defined Markov chain. From this chain, estimates of the rigid state of the structure can be obtained by a simple averaging process. O.C.

A85-49922
ACTIVE CONTROL OF SPACE STRUCTURES BY MODEL ERROR SENSITIVITY SUPPRESSION
J. SESAK (General Dynamics Corp., Convair Div., San Diego, CA) SAWE, Annual Conference, 43rd, Atlanta, GA, May 21-23, 1984. 13 p. refs
(SAWE PAPER 1623)

This paper provides an introduction to the large space structure control problem and outlines a solution methodology based on an extended linear optimal control algorithm, Model Error Sensitivity Suppression (MESS). This algorithm provides simultaneous solution for the static and dynamic problems of flexible spacecraft control. A numerical example is provided that illustrates the properties of the algorithm. Author

A85-49923* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
COMPUTER-AIDED CONTROLLABILITY ASSESSMENT OF GENERIC MANNED SPACE STATION CONCEPTS
M. J. FEREBEE, L. J. DERYDER (NASA, Langley Research Center, Hampton, VA), and M. L. HECK (Analytical Mechanics Associates, Inc., Hampton, VA) SAWE, Annual Conference, 43rd, Atlanta, GA, May 21-23, 1984. 29 p.
(SAWE PAPER 1624)

NASA's Concept Development Group assessment methodology for the on-orbit rigid body controllability characteristics of each generic configuration proposed for the manned space station is presented; the preliminary results obtained represent the first step in the analysis of these eight configurations. Analytical computer models of each configuration were developed by means of the Interactive Design Evaluation of Advanced Spacecraft CAD system, which created three-dimensional geometry models of each configuration to establish dimensional requirements for module connectivity, payload accommodation, and Space Shuttle berthing; mass, center-of-gravity, inertia, and aerodynamic drag areas were then derived. Attention was also given to the preferred flight attitude of each station concept. O.C.

N85-22398*# Stanford Univ., Calif. Electronics Labs.
MODEL REDUCTION FOR CONTROL SYSTEM DESIGN Final Report
D. F. ENNS Mar. 1985 305 p refs
(Contract NAG2-223)
(NASA-CR-170417; NAS 1.26:170417) Avail: NTIS HC A14/MF A01 CSCL 01C

An approach and a technique for effectively obtaining reduced order mathematical models of a given large order model for the purposes of synthesis, analysis and implementation of control systems is developed. This approach involves the use of an error criterion which is the H-infinity norm of a frequency weighted error between the full and reduced order models. The weightings are chosen to take into account the purpose for which the reduced order model is intended. A previously unknown error bound in the H-infinity norm for reduced order models obtained from internally balanced realizations was obtained. This motivated further development of the balancing technique to include the frequency dependent weightings. This resulted in the frequency weighted balanced realization and a new model reduction technique. Two approaches to designing reduced order controllers were developed. The first involves reducing the order of a high order controller with an appropriate weighting. The second involves linear quadratic Gaussian synthesis based on a reduced order model obtained with an appropriate weighting. Author

N85-22506*# SRI International Corp., Menlo Park, Calif.
LABORATORY STUDIES OF SPACECRAFT RESPONSE TO TRANSIENT DISCHARGE PULSES
J. E. NANEVICZ and R. C. ADAMO *In* NASA. Lewis Research Center Spacecraft Environ. Interactions Technol., 1983 p 453-463 Mar. 1985 refs
Avail: NTIS HC A99/MF E03 CSCL 22B

The in-orbit measurement of spacecraft discharge properties was investigated. The experiments include design and fabrication of appropriate sensors and effects of spacecraft electromagnetic responses on the interpretation of the discharge data. Electric field sensors especially designed to response to high-speed transient signals were installed on a mock-up of a satellite. The simple mock-up was basically a sheet of aluminum rolled to form a cylinder. A movable spark-discharge noise source designed to be electromagnetically isolated from its power supply system was used to induce transient signals at various locations on the spacecraft's outer surface. The measurements and their implications are described. It is concluded that practical orbital measurements to define discharge noise source properties should be possible, and that simple mock-ups of the type described below are useful in sensor system design and data interpretation.
E.A.K.

N85-22524# Toronto Univ., Downsview (Ontario). Inst. for Aerospace Studies.
A QUANTITATIVE COMPARISON OF ACTIVE AND PASSIVE DAMPING FOR LARGE SPACE STRUCTURES
F. SHEN Feb. 1985 78 p refs
(UTIAS-TN-249; ISSN-0082-5263; AD-B091300L) Avail: NTIS HC A05/MF A01

A quantitative method for comparing active and passive damping according to weight and positivity criteria is outlined which assumes thruster actuators for active damping and viscoelastic material for passive damping. Each of these damping techniques is implemented by optimizing the damping performance against weight. The Mobile Communications Satellite (MSAT) is used as a model to compare active and passive damping. The results show that, in general, active damping is much more weight-cost effective and possesses better positivity qualities than passive damping. Until the design of the active system incorporates a filter for observation noise that is equal in magnitude to the disturbance noise, passive damping will not be more weight-cost effective than active damping.
A.R.H.

N85-22612# AEG-Telefunken, Wedel (West Germany).
BLANKET INTEGRATED CUSHIONING OF FOLDABLE AND RETRACTABLE SOLAR ARRAYS
J. KOCH *In* ESA Photovoltaic Generators in Space p 335-343 Nov. 1984 refs
Avail: NTIS HC A20/MF A01

Design and development of solar blanket integrating cushioning (BIC) options, and selection of concepts are described. Tests with components and modules to increase knowledge of material properties are summarized. Dynamic tests with a representative sample, consisting of several folds in stowed configuration and subjected to sinusoidal vibration under variation of boundary conditions, such as preload of the stack are outlined. For shuttle launch, a partial contact system is best, although a full contact (no BIC) design with throw away foil cushioning is feasible.
Author (ESA)

N85-23100*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
SPLINE-BASED RAYLEIGH-RITZ METHODS FOR THE APPROXIMATION OF THE NATURAL MODES OF VIBRATION FOR FLEXIBLE BEAMS WITH TIP BODIES Final Report
I. G. ROSEN Mar. 1985 33 p refs Submitted for publication
(Contract NAS1-17070; AF-AFOSR-0393-84)
(NASA-CR-172566; ICASE-85-22; NAS 1.26:172566) Avail: NTIS HC A03/MF A01 CSCL 20K

Rayleigh-Ritz methods for the approximation of the natural modes for a class of vibration problems involving flexible beams with tip bodies using subspaces of piecewise polynomial spline functions are developed. An abstract operator theoretic formulation of the eigenvalue problem is derived and spectral properties investigated. The existing theory for spline-based Rayleigh-Ritz methods applied to elliptic differential operators and the approximation properties of interpolatory splines are useed to argue convergence and establish rates of convergence. An example and numerical results are discussed.
Author

N85-23351# California Univ., Los Angeles.
APPROXIMATION IN OPTIMAL CONTROL AND IDENTIFICATION OF LARGE SPACE STRUCTURES Final Scientific Report, 15 Aug. 1983 - 14 Aug. 1984
J. S. GIBSON Jan. 1985 18 p
(Contract AF-AFOSR-0317-83)
(AD-A150323; AFOSR-85-0049TR) Avail: NTIS HC A02/MF A01 CSCL 12A

This project dealt with the application of distributed system theory to control and identification of large flexible space structures. The main analytical tools were control theory for infinite dimensional systems and approximation theory for distributed systems. Both theoretical results and practical numerical approximation schemes were developed. The research dealt with both continuous-time and discrete-time control and identification. In each case, an ideal infinite dimensional compensator was used to guide the design of implementable finite dimensional compensators. Most of the research dealt with optimal linear-quadratic control theory, but significant preliminary results were obtained on infinite dimensional autoregressive-moving-average models of distributed systems. These models will be used in adaptive control and identification of flexible space structures.
GRA

N85-23836*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
VERIFICATION FOR LARGE SPACE STRUCTURES
J. CHEN and J. GARBA *In* NASA. Langley Research Center Large Space Antenna Systems Technol., 1984 p 393-406 Apr. 1985
Avail: NTIS HC A20/MF A01 CSCL 22B

The primary concern for verification is the dynamic characteristics of the space structure related to the control and sensor/actuator location. Properties such as modal density, range of natural frequencies, and modal displacements at the sensor/actuator location are considered and are simulated for the verification of the structure/control closed loop system. A space beam is studied in zero gravity environment and in a 1 G gravity environment, along with their governing equations.
E.R.

N85-23838*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
STRUCTURAL DYNAMICS ANALYSIS
J. M. HOUSNER, M. ANDERSON, W. BELVIN, and G. HORNER *In its* Large Space Antenna Systems Technol., 1984 p 423-445 Apr. 1985
Avail: NTIS HC A20/MF A01 CSCL 22B

Dynamic analysis of large space antenna systems must treat the deployment as well as vibration and control of the deployed antenna. Candidate computer programs for deployment dynamics, and issues and needs for future program developments are reviewed. Some results for mast and hoop deployment are also presented. Modeling of complex antenna geometry with conventional finite element methods and with repetitive exact elements is considered. Analytical comparisons with experimental results for a 15 meter hoop/column antenna revealed the importance of accurate structural properties including nonlinear joints. Slackening of cables in this antenna is also a consideration. The technology of designing actively damped structures through analytical optimization is discussed and results are presented.
Author

N85-23839*# Air Force Wright Aeronautical Labs., Wright-Patterson AFB, Ohio. Flight Dynamics Lab.
AFWAL SPACE CONTROL TECHNOLOGY PROGRAM
V. O. HOEHNE *In* NASA. Langley Research Center Large Space Antenna Systems Technol., 1984 p 447-463 Apr. 1985 refs
Avail: NTIS HC A20/MF A01 CSCL 22B

An overview of space oriented control technology programs which are applicable to flexible large space structures is presented. The spacecraft control activity is interdisciplinary with activities in structures, structural dynamics and control brought together. The large flexible structures to be controlled have many physical factors that influence the final controllability of the vehicle. Factors are studied such as rigidity of both structural elements and joints, damping inherent in both material as well as discrete dampers located throughout the structure, and the bandwidth of both sensors and actuators used to sense motion and control it. Descriptions of programs both in-house and contracted are given. E.R.

N85-23841*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
ON-ORBIT SYSTEMS IDENTIFICATION OF FLEXIBLE SPACECRAFT TECHNOL., 1984, PT. 2 P 465-481
L. TAYLOR and L. D. PINSON *In its* Large Space Antenna Systems Technol., 1984, Pt. 2 p 465-481 Apr. 1985 refs
Avail: NTIS HC A21/MF A01 CSCL 22B

Future spacecraft include configurations which are too flexible to be adequately tested prior to flight and which will require on-orbit systems identification to ensure safe operation of the flight control system. The structural dynamics model will evolve and its accuracy will improve in stages as ground tests of full-scale components and replica-scale models are performed. State Space Modeling and Conditional Maximum Likelihood Parameter Estimation methodology can provide the formal probability-based framework for the process of upgrading a model as additional test results are obtained. Although the number of unknown parameters can be reduced by the use of canonical forms for the stability matrix, the number of unknown model parameters quickly becomes unmanageable unless advantage is taken of the relationship of a much fewer number of global model parameters. Distributed parameter systems or partial differential equation models are one way to take advantage of such global parameters to reduce the number of unknown model parameters. B.G.

N85-23842*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
AN EIGENSYSTEM REALIZATION ALGORITHM FOR APPLICATION TO MODAL TESTING
J. N. JUANG *In its* Large Space Antenna Systems Technol., 1984, Pt. 2 p 483-502 Apr. 1985 refs
Avail: NTIS HC A21/MF A01 CSCL 09B

Important features of the Eigensystem Realization Algorithm (ERA) are summarized as follows: (1) from the computational standpoint, the algorithm is attractive, since only simple numerical operations are needed; (2) the computational procedure is numerically stable; (3) the structural dynamics requirements for modal parameter identification and the control design requirements for a reduced-state space model are satisfied; (4) data from more than one test can be used simultaneously to efficiently identify the closely spaced eigenvalues; and (5) no restrictions on number of measurements are imposed. Author

N85-23843*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
MSFC DATA ANALYSIS OF THE SAFE/DAE EXPERIMENT
R. W. SCHOCK, T. E. NESMAN, and D. K. REED *In* NASA. Langley Research Center Large Space Antenna Systems Technol., 1984, Pt. 2 p 505-516 Apr. 1985
Avail: NTIS HC A21/MF A01 CSCL 22B

The Solar Array Flight Experiment (SAFE) on-orbit experiment for measurement of large structures dynamics consists of a dynamic sensing system designed to record and analyze the dynamic characteristics of the SAFE. The early availability of the SAFE and its basic large space structure characteristics made it a logical candidate for verification of the sensing system and evaluation technique. The characteristics of the solar array which place it well within the generic class of large space structures are: (1) Large size; (2) Low natural frequencies; (3) Mechanical complexity of its extendable/retractable mast; and (4) The inability to dynamic test in Earth atmosphere and one g. G.L.C.

N85-23844*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
LANGLEY RESEARCH CENTER PHOTOGRAMMETRIC MEASUREMENTS OF SOLAR ARRAY DYNAMICS: PRELIMINARY RESULTS
M. L. BRUMFIELD, R. S. PAPPA, J. B. MILLER, and R. R. ADAMS *In its* Large Space Antenna Systems Technol., 1984, Pt. 2 p 577-545 Apr. 1985
Avail: NTIS HC A21/MF A01 CSCL 10A

The NASA Langley Research Center participated in the Solar Array Experiment with two primary objectives: (1) to study the structural and control dynamics of a new class of large, lightweight, low-frequency space structures, and (2) to develop technology for remote video measurement of structural motions. The shuttle orbiter's closed circuit television (CCTV) system was used to provide recorded video images of the solar array from four locations in the payload bay, two on the forward bulkhead and two on the aft bulkhead. White reflective targets were placed on the array to provide discrete points at which to track array motion. A dynamic test consisted of a quiescent period in which orbiter operations were inhibited and crew motion restricted, an excitation period, and a free decay period. The orbiter was placed in free drift while in a gravity gradient orientation and dynamics tests were timed to occur at orbital noon so that the Sun would illuminate one side of the array and Earth albedo the other. The CCTV system was turned on during the quiescent period, approximately 3 minutes prior to excitation. Video from all four CCTV cameras was recorded continuously through the excitation and free-decay periods for a total test record of 8 to 10 minutes. G.L.C.

N85-23845*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
LARGE ANTENNA CONTROL METHODS: CURRENT STATUS AND FUTURE TRENDS
G. RODRIGUEZ, Y. H. LIN, and M. H. MILMAN *In* NASA. Langley Research Center Large Space Antenna Systems Technol., 1984, Pt. 2 p 547-568 Apr. 1985 refs
Avail: NTIS HC A21/MF A01 CSCL 22B

Current methods for control of large antennas, as well as future trends required for improved performance are addressed. Some of the target missions in which these methods would be used are: the Land Mobile Satellite System (LMSS) for communications; the Satellite Surveillance (SSS) for aircraft traffic control; the orbiting Very Long Baseline Interferometer (VLBI), or QUASAT, for radio astronomy; and the Large Deployable Reflector (LDR) for IR and submillimeter astronomy. G.L.C.

N85-23846*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
EXPERIMENTAL DEVELOPMENT OF A FAILURE DETECTION SCHEME FOR LARGE SPACE STRUCTURES
R. C. MONTGOMERY and J. P. WILLIAMS *In its* Large Space Antenna Systems Technol., 1984, Pt. 2 p 569-589 Apr. 1985
Avail: NTIS HC A21/MF A01 CSCL 22B

Large flexible spacecraft may require control systems consisting of large numbers of sensors and actuators. To assure a viable mission, the control system should tolerate failures of some of the control components. Hence, it is desirable to automate the process of failure detection, identification, and control system reconfiguration (FDI&R). Some of the opportunities to accommodate failure in the spacecraft design are reviewed. Some methods for FDI&R are presented in overview, and the method chosen for experimental testing is described. Finally, the experimental activities leading to the validation of the technique are presented. G.L.C.

N85-23847*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
DYNAMIC VERIFICATION OF LARGE SPACE STRUCTURES
D. K. TOLLISON (Control Dynamics Co., Huntsville, Ala.) and H. B. WAITES *In* NASA. Langley Research Center Large Space Antenna Systems Technol., 1984, Pt. 2 p 591-601 Apr. 1985
Avail: NTIS HC A21/MF A01 CSCL 22B

The Marshall Space Flight Center developed a facility in which closed-loop control of large space structures (LSS) can be demonstrated and verified. The main objective of the facility is to verify LSS control system techniques so that on-orbit performance can be ensured. The facility consists of an LSS test article which is connected to a payload mounting system that provides control torque commands. It is attached to a base excitation system which simulates disturbances most likely to occur for orbiter and DOD payloads. A control computer contains the calibration software, the reference system, the alignment procedures, the telemetry software, and the control algorithms. The total system will be suspended in such a fashion that the LSS test article has the characteristics common to all LSS. M.G.

N85-23848*# Martin Marietta Corp., Denver, Colo.
PASSIVE AND ACTIVE CONTROL OF SPACE STRUCTURES (PACOSS)
G. MOROSOW, H. HARCROW, and L. ROGERS (Air Force Wright Aeronautical Labs., Dayton, Ohio) *In* NASA. Langley Research Center Large Space Antenna Systems Technol., 1984, Pt. 2 p 603-615 Apr. 1985
Avail: NTIS HC A21/MF A01 CSCL 22B

Passive and Active Control of Space Structures (PACOSS) is a five-year program designed to investigate highly damped structures in conjunction with active control systems, and in particular to develop technology that integrates passive damping and active control to achieve precise pointing control. Major areas of research include metal matrix composites; viscoelastic materials; damping devices; dynamic test article design, fabrication and testing; and active damping. M.G.

N85-23849*# Harris Corp., Melbourne, Fla.
APPLICATION OF THE MAXIMUM ENTROPY/OPTIMAL PROJECTION CONTROL DESIGN APPROACH FOR LARGE SPACE STRUCTURES
D. C. HYLAND *In* NASA. Langley Research Center Large Space Antenna Systems Technol., 1984, Pt. 2 p 617-654 Apr. 1985 refs
Avail: NTIS HC A21/MF A01 CSCL 22B

The underlying philosophy and motivation of the optimal projection/maximum entropy (OP/ME) stochastic modelling and reduced order control design method for high order systems with parameter uncertainties are discussed. The OP/ME design equations for reduced-order dynamic compensation including the effect of parameter uncertainties are reviewed and the application of the methodology to several large space structure (LSS) problems of representative complexity is illustrated. M.G.

N85-23864*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
CONTROL OF FLEXIBLE STRUCTURES (COFS) FLIGHT EXPERIMENT BACKGROUND AND DESCRIPTION
B. R. HANKS *In its* Large Space Antenna systems Technol., 1984, Pt. 2 p 893-908 Apr. 1985
Avail: NTIS HC A21/MF A01 CSCL 22B

A fundamental problem in designing and delivering large space structures to orbit is to provide sufficient structural stiffness and static configuration precision to meet performance requirements. These requirements are directly related to control requirements and the degree of control system sophistication available to supplement the as-built structure. Background and rationale are presented for a research study in structures, structural dynamics, and controls using a relatively large, flexible beam as a focus. This experiment would address fundamental problems applicable to large, flexible space structures in general and would involve a combination of ground tests, flight behavior prediction, and instrumented orbital tests. Intended to be multidisciplinary but basic within each discipline, the experiment should provide improved understanding and confidence in making design trades between structural conservatism and control system sophistication for meeting static shape and dynamic response/stability requirements. Quantitative results should be obtained for use in improving the validity of ground tests for verifying flight performance analyses. A.R.H.

N85-23868# Toronto Univ., Downsview (Ontario). Inst. for Aerospace Studies.
DAMPING MODELS FOR FLEXIBLE COMMUNICATIONS SATELLITES BY SUBSTRUCTURAL DAMPING SYNTHESIS
P. C. HUGHES Jan. 1985 62 p refs
(UTIAS-287; ISSN-0082-5255; AD-B091437L) Avail: NTIS HC A04/MF A01

Most modern spacecraft are structurally flexible and, moreover, these spacecraft can naturally and profitably be analyzed as a collection of attached substructures (solar array panels, antennas, thermal radiators, etc.). Various models are combined for substructural energy dissipation so that an overall damping model for the spacecraft results. (Four such substructural damping models are discussed, two of which are shown to produce the same results.) Such a synthesis procedure proves valuable when substructural damping data is known, either from ground tests or detailed analysis. B.W.

N85-23902 Purdue Univ., West Lafayette, Ind.
MODEL AND CONTROLLER REDUCTION OF UNCERTAIN SYSTEMS USING COVARIANCE EQUIVALENT REALIZATIONS Ph.D. Thesis
D. A. WAGIE 1984 228 p
Avail: Univ. Microfilms Order No. DA8500451

A theory to design a controller that is of smaller dimension than the original system, and the parameters of the system are considered uncertain. The general approach is to use a projection technique for system reduction which provides a reduced system that matches output covariances and Markov parameters of the original system. This technique preserves the mean-squared values of the system outputs, and important property since most performance specifications are given in terms of maximum mean-squared output values. A concise theoretical development of the proposed projection approach to system reduction is provided and its application for model and controller reduction of both continuous and discrete systems is discussed. This technique is then used to design a reduced sensitivity controller for a continuous time system with uncertain parameters. Dissert. Abstr.

N85-23903*# California Univ., Los Angeles.
A MATHEMATICAL FORMULATION OF THE SCOLE CONTROL PROBLEM, PART 1
A. V. BALAKRISHNAN May 1985 43 p refs
(Contract NAG1-464)
(NASA-CR-172581; NAS 1.26:172581) Avail: NTIS HC A03/MF A01 CSCL 22B

A mathematical formulation of the SCOLE control problem in terms of a continuous model described by partial differential equations with delta functions on the boundary is presented along with three techniques of solution. The abstract wave equation approach leads immediately to a linear feedback law that can ensure (strong) stability. The boundary control approach yields an explicit solution, albeit in a simple case. Author

N85-23923# Integrated Systems, Inc., Palo Alto, Calif.
ADAPTIVE TECHNIQUES FOR CONTROL OF LARGE SPACE STRUCTURES Final Report, 1 Jun. 1983 - 31 May 1984
R. L. KOSUT and M. G. LYONS Dec. 1984 141 p
(Contract F49620-83-C-0107)
(AD-A150957; AFOSR-85-0078TR) Avail: NTIS HC A07/MF A01 CSCL 22B

This report is a collection of published papers reporting on research supported by AFOSR. These papers deal primarily with theoretical aspects of adaptive control of systems which cannot

be precisely modeled, e.g., unmodeled dynamics and disturbances. These latter characteristics are fundamental issues in adaptive (and nonadaptive) control design for large space structures (LSS). Some of the general topics covered include: LSS modeling and model error, decentralized control, robust adaptive control, global stability, local stability, and persistent excitation. GRA

N85-23992# Little (Arthur D.), Inc., Cambridge, Mass.
TECHNICAL AND COST ANALYSES OF MANGANESE NODULE PROCESSING TECHNIQUES AND THEIR SIGNIFICANT VARIATIONS Final Report, 4 Feb. 1983 - 30 Sep. 1984
Sep. 1984 277 p
(Contract NA83SA-C-00637)
(PB85-148815; ADL-REF-89093-F; OME-84/1) Avail: NTIS HC A13/MF A01 CSCL 11F

Literature was reviewed with respect to the metallurgical processing of deep seabed manganese nodules and each of five process options was examined in detail to estimate: optimum production rate; capital and operating costs, as well as that portion of each ascribed to the cost of compilance with environmental regulations; socioeconomic impacts; and, the role of manganese, including the rate of manganese mined but not initially marketed. An annotated bibliography containing 104 references is included. Author (GRA)

N85-24817# Systems Engineering for Power, Inc., Vienna, Va.
MODELING AND CONTROL OF LARGE FLEXIBLE STRUCTURES, PHASE 1 Final Report, 30 Sep. 1983 - 31 May 1984
B. AVRAMOVIC, N. BARKAKATI, W. BENNET, G. L. BLANKENSHIP, and H. G. KWATNY 31 Jul. 1984 188 p
(Contract F49620-83-C-0159)
(AD-A150736; SEPI-TR-84-9; AFOSR-85-0075TR) Avail: NTIS HC A09/MF A01 CSCL 12A

The main emphasis in the first phase of this work has been the adaptation and enhancement of certain Wiener-Hopf methods for control system design used by J. Davis for treatment of linear, dynamic, distributed parameter models of flexible structures. The numerical algorithms for executing the spectral factorization were based on some earlier work of F. Stenger. The Davis-Stenger methodology was adapted to the problem of vibration control of flexible structures. The spectral factorization methodology avoids the difficult numerical problems associated with the solution of the Riccati partial differential equations which arise in the time domain approach for designing stabilizing controllers. In this way distributed phenomena, like travelling waves, which characterize the macroscopic dynamics of flexible structures are retained in the model, and their interaction with the control system is preserved in the analytical design process. Computational algorithms were developed and several prototype systems were treated including the Euler Beam and a simple two dimensional system. Second part of the research involved the use of a mathematical technique for asymptotic analysis called homogenization. Homogenization of the model for a structure with a regular infrastructure produces a model with smoothly varying effective parameters for mass density, local tension, and damping that represents a flexible structure with a uniform homogenized internal structure. GRA

N85-25375*# Smithsonian Astrophysical Observatory, Cambridge, Mass.
THE INVESTIGATION OF TETHERED SATELLITE SYSTEM DYNAMICS Quarterly Report, 1 Dec. 1984 - 14 Feb. 1985
E. LORENZINI Mar. 1985 117 p refs
(Contract NAS8-36160)
(NASA-CR-171433; NAS 1.26:171433; QR-2) Avail: NTIS HC A06/MF A01 CSCL 22B

A progress report is presented that deals with three major topics related to Tethered Satellite System Dynamics. The SAO rotational dynamics computer code was updated. The program is now suitable to deal with inclined orbits. The output has been also modified in order to show the satellite Euler angles referred to the rotating orbital frame. The three-dimensional high resolution computer program SLACK3 was developed. The code simulates the three-dimensional dynamics of a tether going slack taking into account the effect produced by boom rotations. Preliminary simulations on the three-dimensional dynamics of a recoiling slack tether are shown in this report. A program to evaluate the electric potential around a severed tether is immersed in a plasma. The potential is computed on a three-dimensional grid axially symmetric with respect to the tether longitudinal axis. The electric potential variations due to the plasma are presently under investigation. B.W.

N85-25377*# Control Dynamics Co., Huntsville, Ala.
DEFINITION OF GROUND TEST FOR VERIFICATION OF LARGE SPACE STRUCTURE CONTROL Progress Report, 1 - 31 Mar. 1985
S. M. SELTZER and G. B. DOANE, III 4 Apr. 1985 18 p
(Contract NAS8-35835)
(NASA-CR-171438; NAS 1.26:171438; PR-10) Avail: NTIS HC A02/MF A01 CSCL 22B

Directions regarding the analytical models were received. A counter balance arm with weights was added at the top of the ASTROMAST to offset the arm with the gimbals. In addition to this model, three more models were requested from MSFC: structure as in the revised model with the addition of lumped masses at bays 46 and 91 of the ASTROMAST; cantilevered cruciform structure with lumped masses at bays 46 and 91, and an all up cruciform structure with lumped masses at bays 46 and 91. Figures for each model and their corresponding natural frequencies and general mode shapes associated with these frequencies are included. The drawbar in use in the cruciform models must be incorporated into the antenna and ASTROMAST models. The total tensile load carrying capability of the ASTROMAST is approximately 840 pounds. A.R.H.

N85-25895*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
STRUCTURES AND DYNAMICS DIVISION RESEARCH AND TECHNOLOGY PLANS FOR FY 1985 AND ACCOMPLISHMENTS FOR FY 1984
K. S. BALES Apr. 1985 102 p
(NASA-TM-86417; NAS 1.15:86417) Avail: NTIS HC A06/MF A01 CSCL 20K

The objectives, FY 1985 plans, approach, and FY 1985 milestones for the Structures and Dynamics Division's research programs are presented. The FY 1984 accomplishments are presented where applicable. This information is useful in program coordination with other government organizations in areas of mutual interest. E.A.K.

N85-26259# Maryland Univ., College Park. Dept. of Aerospace Engineering.
DEVELOPMENT OF A DYNAMIC FINITE ELEMENT MODEL FOR UNRESTRAINED FLEXIBLE STRUCTURES Final Report, 1 Sep. 1982 - 30 Jun. 1984
E. R. CHRISTENSEN and S. W. LEE Oct. 1984 145 p
(Contract AF-AFOSR-0296-82)
(AD-A151176; AFOSR-85-0183TR) Avail: NTIS HC A07/MF A01 CSCL 12A

An efficient finite element model and solution technique have been developed for the analysis of unrestrained flexible structures undergoing large elastic deformations coupled with gross nonsteady translational and rotational motions with respect to an inertial reference frame. The nonlinear coupled differential equations resulting from the finite element approximation are integrated timewise using an implicit-explicit split operator numerical integration scheme which treats the stability sensitive terms of the equation implicitly while the rest of the equation is treated explicitly. The motion of simple spacecraft structures consisting of flexible beams attached to rigid masses and including the effect of control forces has been studied using three-node eighteen-degree-of-freedom three dimensional beam elements based on the total Lagrangian description. GRA

N85-26850*# Virginia Polytechnic Inst. and State Univ., Blacksburg. Dept. of Engineering Science and Mechanics.
IDENTIFICATION AND CONTROL OF STRUCTURES IN SPACE Progress Report, 1 Jul. - 31 Dec. 1984
L. MEIROVITCH, R. D. QUINN, and M. A. NORRIS 1984 18 p refs
(Contract NAG1-225)
(NASA-CR-175790; NAS 1.26:175790) Avail: NTIS HC A02/MF A01 CSCL 22B

The derivation of the equations of motion for the Spacecraft Control Laboratory Experiment (SCOLE) is reported and the equations of motion of a similar structure orbiting the earth are also derived. The structure is assumed to undergo large rigid-body maneuvers and small elastic deformations. A perturbation approach is proposed whereby the quantities defining the rigid-body maneuver are assumed to be relatively large, with the elastic deformations and deviations from the rigid-body maneuver being relatively small. The perturbation equations have the form of linear equations with time-dependent coefficients. An active control technique can then be formulated to permit maneuvering of the spacecraft and simultaneously suppressing the elastic vibration. E.A.K.

N85-26854*# Smithsonian Astrophysical Observatory, Cambridge, Mass.
THE INVESTIGATION OF TETHERED SATELLITE SYSTEM DYNAMICS Quarterly Report, 15 Feb. - 14 May 1985
E. LORENZINI Jun. 1985 57 p
(Contract NAS8-36160)
(NASA-CR-175855; NAS 1.26:175855; QR-3) Avail: NTIS HC A04/MF A01 CSCL 22B

The tether control law to retrieve the satellite was modified in order to have a smooth retrieval trajectory of the satellite that minimizes the thruster activation. The satellite thrusters were added to the rotational dynamics computer code and a preliminary control logic was implemented to simulate them during the retrieval maneuver. The high resolution computer code for modelling the three dimensional dynamics of untensioned tether, SLACK3, was made fully operative and a set of computer simulations of possible tether breakages was run. The distribution of the electric field around an electrodynamic tether in vacuo severed at some length from the shuttle was computed with a three dimensional electrodynamic computer code. Author

N85-26857# Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Engineering.
MODEL REDUCTION TECHNIQUES APPLIED TO THE CONTROL OF LARGE SPACE STRUCTURES M.S. Thesis
D. W. VARHOLA Dec. 1984 126 p
(AD-A151784; AFIT/GA/AA/84D-11) Avail: NTIS HC A07/MF A01 CSCL 14B

Three model reduction techniques were examined for their applicability to large lightly damped systems. Frequency truncation, modal cost analysis, and approximate internal balancing methods are applied to the CSDL I and II models. Two actuator/sensor configurations are investigated on the CSDL I. Control of the CSDL I model is implemented through the use of the steady state optimal regulator theory, and the effect of various reduced order control models on the structure's time response is detailed. Modal cost analysis and internal balancing yield is essentially equivalent results for the cases chosen, although the internal balancing technique provides more information concerning actuator/sensor effectiveness. These methods provide more effective reduced order models for higher order systems than simple frequency truncation. GRA

N85-26858# Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Engineering.
THE EFFECT OF INACCURACIES IN STRUCTURAL MODELS ON THE CONTROL OF LARGE SPACE STRUCTURES M.S. Thesis
S. E. MOORE Dec. 1984 110 p
(AD-A151794; AFIT/GA/AA/84D-6) Avail: NTIS HC A06/MF A01 CSCL 12A

Modern optimal control methods are proposed as a method for controlling the vibration of large space structures. These methods are very dependent on the structural finite element model as a basis for calculating the optimal control. This research investigates the effect of inaccuracies of these structural models on the performance of this type of controller. Any finite element model is a discretization of the actual structure. As such, it is impossible to exactly model the structure because the model is finite and discrete while the structure is continuous. These errors plus those due to inaccurate assumptions or measurements create discrepancies between what the structure is and what the controller is actually designed for. The structural model is used to calculate a number (equal to the number of degrees of freedom) of natural vibration frequencies with their associated mode shapes. These vibration modes can be grouped into four sets; controlled, suppressed, residual and unmodeled. The structural model used for this research is the Charles Stark Draper Laboratory Model 1 (CSDL1). It is a tetrahedral truss with four lumped masses yielding twelve degrees of freedom, and hence, twelve vibratory modes. GRA

N85-27935*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
SOLAR ARRAY FLIGHT EXPERIMENT
J. SLABY Apr. 1985 17 p
(NASA-TM-86506; NAS 1.15:86506) Avail: NTIS HC A02/MF A01 CSCL 22B

This is a closed form solution for the longitudinal oscillation of the Solar Array Flight Experiment (SAFE) blanket for all phases of deployment. The frequency response shows that the blanket frequency increases shortly before full deployment. That fact causes a coupling between the mast and the blanket frequency but, because of the relatively high speed of deployment, a buildup of resonance is unlikely. Author

N85-27937# Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Engineering.
INCORPORATING CONTROL INTO THE OPTIMAL STRUCTURAL DESIGN OF LARGE FLEXIBLE SPACE STRUCTURES M.S. Thesis
T. V. MUCKENTHALER Dec. 1984 139 p
(AD-A152858; AFIT/GA/AA/84D-7) Avail: NTIS HC A07/MF A01 CSCL 22B

An eigenspace optimization approach is used to incorporate optimal control into the structural design process for large flexible space structures. The equations of motion for an uncontrolled system are developed by deriving the kinetic and potential energy for the system and then using assumed modes to discretize the energies. These expressions are then linearized, the Lagrangian formed, and Lagrange equations written for the system. An existing optimal control law is incorporated to form the equations of motion for the controlled system. A parameter optimization technique is used to minimize the mass of the Draper/RPL configuration model involving eigenspace optimization. A computer algorithm is developed that effectively optimizes a global structural parameter vector to minimize the mass of the model, while constraining specified eigenvalues. The eigenvalue sensitivities are passed to a constrained function minimization program called CONMIN which minimizes the mass of the appendages. The constraints imposed restrict the first eigenvalue to the left half plane and the natural frequency of the third eigenvalue to a specified stable region. The result is an algorithm that incorporates an existing optimal control law into the structural optimization process. GRA

N85-27939# Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Engineering.
MATHEMATICAL MODELING AND CONTROL OF A LARGE SPACE STRUCTURE AS APPLIED TO A SHUTTLE-ANTENNA CONFIGURATION M.S. Thesis
J. O. DUNSTAN Dec. 1984 131 p
(AD-A153269; AFIT/GA/AA/84D-3) Avail: NTIS HC A07/MF A01 CSCL 22B

The equations of motion of a flexible shuttle-beam-antenna system are developed and discretized using an assumed modes approximation. The system was modeled as a cantilever beam rigidly attached to the shuttle with the motion of the antenna accounted for as forces and moments on the beam's free end. The equations of motion for the system were formed from the linearized kinetic and potential energies using Lagrange's method. The equations were put into matrix form, and the matrices were diagonalized. Linear optimal regulator techniques were employed to control the system. Two proof-mass actuators were modeled at the 40- and 80-foot positions along the beam. The shuttle was assumed to be able to be torqued about it's axes, as was the antenna. Initial runs of the ACOSS computer program showed the system to be stable with unit weighting on the weighting matrix. The system was driven unstable by changing the weightings on the flexible modes. The suppression algorithm in the program re-stabilized the system, as expected. GRA

N85-29537*# California Univ., Berkeley. Dept. of Mechanical Engineering.
DYNAMIC CONSIDERATIONS FOR CONTROL OF CLOSED LIFE SUPPORT SYSTEMS
P. S. BABCOCK, D. M. AUSLANDER, and R. C. SPEAR *In* NASA. Ames Research Center Controlled Ecol. Life Support System p 47-54 Jun. 1985 refs
Avail: NTIS HC A04/MF A01 CSCL 06K

Reliability of closed life support systems depend on their ability to continue supplying the crew's needs during perturbations and equipment failures. The dynamic considerations interact with the basic static design through the sizing of storages, the specification of excess capacities in processors, and the choice of system initial state. A very simple system flow model was used to examine the possibilities for system failures even when there is sufficient storage to buffer the immediate effects of the perturbation. Two control schemes are shown which have different dynamic consequences in response to component failures. E.A.K.

N85-29995*# Howard Univ., Washington, D. C. Dept. of Mechanical Engineering.
ON THE ACCURACY OF MODELLING THE DYNAMICS OF LARGE SPACE STRUCTURES
C. M. DIARRA and P. M. BAINUM Oct. 1985 11 p refs Proposed for presentation at the 36th Intern. Astronautical Congr., Stockholm, 7-12 Oct. 1985
(Contract NSG-1414)
Avail: NTIS HC A02/MF A01 CSCL 22B

Proposed space missions will require large scale, light weight, space based structural systems. Large space structure technology (LSST) systems will have to accommodate (among others): ocean data systems; electronic mail systems; large multibeam antenna systems; and, space based solar power systems. The structures are to be delivered into orbit by the space shuttle. Because of their inherent size, modelling techniques and scaling algorithms must be developed so that system performance can be predicted accurately prior to launch and assembly. When the size and weight-to-area ratio of proposed LSST systems dictate that the entire system be considered flexible, there are two basic modeling methods which can be used. The first is a continuum approach, a mathematical formulation for predicting the motion of a general orbiting flexible body, in which elastic deformations are considered small compared with characteristic body dimensions. This approach is based on an a priori knowledge of the frequencies and shape functions of all modes included within the system model. Alternatively, finite element techniques can be used to model the entire structure as a system of lumped masses connected by a series of (restoring) springs and possibly dampers. In addition, a computational algorithm was developed to evaluate the coefficients of the various coupling terms in the equations of motion as applied to the finite element model of the Hoop/Column. F.M.R.

N85-29996*# Howard Univ., Washington, D. C. School of Engineering.
THE DYNAMICS AND CONTROL OF LARGE FLEXIBLE SPACE STRUCTURES, 8 Final Report
P. M. BAINUM, A. S. S. R. REDDY, C. M. DIARRA, and S. ANANTHAKRISHNAN Jun. 1985 94 p refs
(Contract NSG-1414)
(NASA-CR-175986; NAS 1.26:175986) Avail: NTIS HC A05/MF A01 CSCL 22B

A development of the in plane open loop rotational equations of motion for the proposed Spacecraft Control Laboratory Experiment (SCOLE) in orbit configuration is presented based on an Eulerian formulation. The mast is considered to be a flexible beam connected to the (rigid) shuttle and the reflector. Frequencies and mode shapes are obtained for the mast vibrational appendage modes (assumed to be decoupled) for different boundary conditions based on continuum approaches and also preliminary results are obtained using a finite element representation of the mast reflector system. The linearized rotational in plane equation is characterized by periodic coefficients and open loop system stability can be examined with an application of the Floquet theorem. Numerical results are presented to illustrate the potential instability associated with actuator time delays even for delays which represent only a small fraction of the natural period of oscillation of the modes contained in the open loop model of the system. When plant and measurement noise effects are added to the previously designed deterministic model of the hoop column system, it is seen that both the system transient and steady state performance are degraded. Mission requirements can be satisfied by appropriate assignment of cost function weighting elements and changes in the ratio of plant noise to measurement noise. Author

N85-30289# Instituto de Pesquisas Espaciais, Sao Jose dos Campos (Brazil).
SPILLOVER MINIMIZATION: AN APPROACH FOR ACTUATORS AND SENSORS PLACEMENT IN DISTRIBUTED PARAMETER STUDY
P. T. DEMELLOLOURENCAO May 1985 6 p refs Presented at the 8th Brazil. Congr. of Mech. Eng., Sao Jose dos Campos, Brazil, 10-13 Dec. 1985
(INPE-3525-PRE/746) Avail: NTIS HC A02/MF A01

A technique for selecting the positions where actuators and sensors should be placed for the control of large flexible systems is presented. For control implementation, the independent modal space control is used for increasing the damping of the dominant modes. Two indices are defined taking into account the importance of each mode as a function of the position over the elastic domain, and are used to reduce the effect of the controller over the nondominant modes. A two dimensional structure is investigated to obtain numerical results. Author

N85-30366*# Kentron International, Inc., Hampton, Va.
APPLICATION OF THE ADAMS PROGRAM TO DEPLOYABLE SPACE TRUSS STRUCTURES
R. E. CALLESON Jul. 1985 43 p refs
(Contract NAS1-18000)
(NASA-CR-177927; NAS 1.26:177927) Avail: NTIS HC A03/MF A01 CSCL 20K

The need for a computer program to perform kinematic and dynamic analyses of large truss structures while deploying from a packaged configuration in space led to the evaluation of several existing programs. ADAMS (automatic dynamic analysis of mechanical systems), a generalized program from performing the dynamic simulation of mechanical systems undergoing large displacements, is applied to two concepts of deployable space antenna units. One concept is a one cube folding unit of Martin Marietta's Box Truss Antenna and the other is a tetrahedral truss unit of a Tetrahedral Truss Antenna. Adequate evaluation of

dynamic forces during member latch-up into the deployed configuration is not yet available from the present version of ADAMS since it is limited to the assembly of rigid bodies. Included is a method for estimating the maximum bending stress in a surface member at latch-up. Results include member displacement and velocity responses during extension and an example of member bending stresses at latch-up. Author

N85-30368*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
DYNAMIC RESPONSE OF A FLEXIBLE SPACE BEAM
M. F. CARD, M. S. ANDERSON, and J. E. WALZ May 1985 19 p refs
(NASA-TM-86441; NAS 1.15:86441) Avail: NTIS HC A02/MF A01 CSCL 20K

Dynamic response of a candidate flexible beam for a space experiment on control of flexible structures is investigated. Studies of natural frequencies reveal a beam length in which torsion and bending frequencies virtually coincide. Eccentric tip mass causes small shifts in natural frequencies but introduces coupled torsional/bending mode shapes. Transient response studies indicate significant effects on tip responses of low damping and first bending mode excitation at higher frequencies. Steady state response suggest displacement and acceleration measurements could be made up to 5 to 12 Hz for the actuator forces/torques assumed. Author

N85-31086 Stanford Univ., Calif.
CONTROL SYSTEM DESIGN FOR LIGHTLY COUPLED LARGE SPACE STRUCTURES Ph.D. Thesis
D. E. BERNARD 1985 151 p
Avail: Univ. Microfilms Order No. DA8506160

This research is concerned with techniques of reducing the control problem to manageable size and making it convenient to use time and frequency domain techniques together in the analysis and improvement of control system designs. Model reduction and system decoupling are complementary methods of reducing a system to manageable size. A model reduction algorithm is presented which extends the class of systems which may be reduced by the balanced realization technique. For system decoupling, an algorithm is presented which approximates a lightly coupled system by a set of decoupled subsystems. For the multi-input/multi-output (MIMO) case, simple, numerically well conditioned algorithms are not readily available to transform frequency domain system descriptions into time domain (state space) form. An efficient, reliable algorithm has been developed to transform the partial fraction expansion of the vast majority of MIMO systems of engineering interest into minimal state space form. Dissert. Abstr.

N85-31087 California Univ., Los Angeles.
DYNAMICS AND CONTROL OF TETHERS IN ELLIPTICAL ORBITS Ph.D. Thesis
P. A. SWAN 1984 205 p
Avail: Univ. Microfilms

The dynamics of rigid tether systems in eccentric orbits are analyzed and control methods for insuring stability are proposed. To accomplish this task, the dynamics of a dumb bell system is studied from the planar, rigid body, orbit coupled, and variable tether length case. The analysis assess the situation for a standard dumb bell tether system and look at the situation for the NASA/Italian experiment. Stability theory and a numerical integration routine (ACSL) used to illustrate the main effects of varying eccentricity and the resulting libration changes. The control aspects studied are centered around two methods of control and three satellite orbital cases. A variation of the Rupp method of changing the tether length to alter the libration is shown in the orbital coupled cases of circular, small eccentric and large eccentric orbits. Both a time controlled method and a libration magnitude controlled case is utilized to provide a better understanding of the elliptical aspects of the tether satellite dynamics. Dissert. Abstr.

N85-31142*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
ADAPTIVE IDENTIFICATION AND CONTROL OF STRUCTURAL DYNAMICS SYSTEMS USING RECURSIVE LATTICE FILTERS
N. SUNDARARAJAN (Indian Space Research Organization), R. C. MONTGOMERY, and J. P. WILLIAMS Jan. 1985 51 p refs
(NASA-TP-2371; L-15737; NAS 1.60:2371) Avail: NTIS HC A04/MF A01 CSCL 22B

A new approach for adaptive identification and control of structural dynamic systems by using least squares lattice filters thar are widely used in the signal processing area is presented. Testing procedures for interfacing the lattice filter identification methods and modal control method for stable closed loop adaptive control are presented. The methods are illustrated for a free-free beam and for a complex flexible grid, with the basic control objective being vibration suppression. The approach is validated by using both simulations and experimental facilities available at the Langley Research Center. Author

N85-31148*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
PROCEEDINGS OF THE WORKSHOP ON IDENTIFICATION AND CONTROL OF FLEXIBLE SPACE STRUCTURES, VOLUME 1
G. RODRIGUEZ, ed. 1 Apr. 1985 469 p refs Workshop held in San Diego, Calif., 4-6 Jul. 1984; sponsored in cooperation with JPL and NASA. Langley Research Center 3 Vol.
(Contract NAS7-918)
(NASA-CR-176051; JPL-PUB-85-29-VOL-1; NAS 1.26:176051)
Avail: NTIS HC A20/MF A01 CSCL 22B

Identification and control of flexible space structures were studied. Exploration of the most advanced modeling estimation, identification and control methodologies to flexible space structures was discussed. The following general areas were discussed: space platforms, antennas, and flight experiments; control/structure interactions - modeling, integrated design and optimization, control and stabilization, and shape control; control technology; control of space stations; large antenna control, dynamics and control experiments, and control/structure interaction experiments.

N85-31150*# Air Force Wright Aeronautical Labs., Wright-Patterson AFB, Ohio.
AFWAL CONTROL TECHNOLOGY PROGRAMS
V. O. HOEHNE *In* JPL Proc. of the Workshop on Identification and Control of Flexible Space Struct., Vol. 1 p 13-36 1 Apr. 1985 refs Previously announced as N85-23839
Avail: NTIS HC A20/MF A01 CSCL 05A

An overview of space oriented control technology programs which are applicable to flexible large space structures is presented. The spacecraft control activity is interdisciplinary with activities in structures, structural dynamics and control brought together. The large flexible structures to be controlled have many physical factors that influence the final controllability of the vehicle. Factors are studied such as rigidity of both structural elements and joints, damping inherent in both material and discrete dampers located throughout the structure, and the bandwidth of both sensors and actuators used to sense motion and control are the physical factors that are interdisciplinary and influence control. GRA

N85-31151*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
MULTIVARIABLE CONTROL OF A SOFT COUPLED SPACE STATION
J. W. SUNKEL and A. F. HOTZ (Purdue Univ., Lafayette, Ind.) *In* JPL Proc. of the Workshop on Identification and Control of Flexible Space Struct., Vol. 1 p 37-50 1 Apr. 1985 refs Previously announced in IAA as A84-43455
Avail: NTIS HC A20/MF A01 CSCL 22B

The paper discusses a multivariate controller design for a control configured space station concept. The space station concept is novel in that mechanical filters (soft couplers) are used to reduce structural interaction between adjacent modules. The primary objective of this study is to provide stability augmentation to the soft coupled configuration. The control objective is achieved by a

state feedback compensator design. To obtain the desired feedback gains, a modified LQR technique is developed which provides prescribed close-loop frequencies and damping ratios.
Author (IAA)

N85-31153*# California Univ., Los Angeles.
AUTOMATIC ASSEMBLY OF SPACE STATIONS
P. K. C. WANG *In* JPL Proc. of the Workshop on Identification and Control of Flexible Space Struct., Vol. 1 p 67-101 1 Apr. 1985 refs
Avail: NTIS HC A20/MF A01 CSCL 22B

A problem in the automatic assembly of space stations is the determination of guidance laws for the terminal rendezvous and docking of two structural components or modules. The problem involves the feedback control of both the relative attitude and translational motion of the modules. A suitable mathematical model based on rigid body dynamics was used. The basic requirements, physical constraints and difficulties associated with the control problem are discussed. An approach which bypasses some of the difficulties is proposed. A nonlinear guidance law satisfying the basic requirements is derived. The implementation requirements is discussed. The performance of the resulting feedback control system with rigid and flexible structural components is studied by computer simulation. E.A.K.

N85-31154*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
SPACE STATION DYNAMIC MODELING, DISTURBANCE ACCOMMODATION, AND ADAPTIVE CONTROL
S. J. WANG, C. H. IH, Y. H. LIN, and E. METTER *In its* Proc. of the Workshop on Identification and Control of Flexible Space Struct., Vol. 1 p 103-139 1 Apr. 1985 refs
Avail: NTIS HC A20/MF A01 CSCL 22B

Dynamic models for two space station configurations were derived. Space shuttle docking disturbances and their effects on the station and solar panels are quantified. It is shown that hard shuttle docking can cause solar panel buckling. Soft docking and berthing can substantially reduce structural loads at the expense of large shuttle and station attitude excursions. It is found predocking shuttle momentum reduction is necessary to achieve safe and routine operations. A direct model reference adaptive control is synthesized and evaluated for the station model parameter errors and plant dynamics truncations. The rigid body and the flexible modes are treated. It is shown that convergence of the adaptive algorithm can be achieved in 100 seconds with reasonable performance even during shuttle hard docking operations in which station mass and inertia are instantaneously changed by more than 100%. E.A.K.

N85-31155*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
DYNAMIC PERFORMANCE OF SEVERAL LARGE ANTENNA CONCEPTS
G. C. ANDERSEN, L. B. GARRETT, and R. E. CALLESON (Kentron International, Hampton, Va.) *In* JPL Proc. of the Workshop on Identification and Control of Flexible Space Struct., Vol. 1 p 141-163 1 Apr. 1985 refs
Avail: NTIS HC A20/MF A01 CSCL 22B

Four antenna concepts the box truss, tetrahedral truss, wrap-radial rib, and hoop and column antenna were examined for the dynamic performance when subjected to an operational environment. Space applications for the concepts are numerous; however, the land mobile satellite system (LMSS) was chosen as a baseline study and its operational constraints are applied to each concept. The dynamic response of each concept is examined for structural displacement and structural damping effects. The necessity of a control system for vibrational displacement reduction is examined along with a comparison of the relative merits of each antenna concept. E.A.K.

N85-31157*# Department of Communications, Ottawa (Ontario). Communications Research Centre.
DESIGN AND EVALUATION OF CONTROL SYSTEMS FOR LARGE COMMUNICATIONS SATELLITES
M. E. STEIBER *In* JPL Proc. of the Workshop on Identification and Control of Flexible Space Struct., Vol. 1 p 183-197 1 Apr. 1985 refs
Avail: NTIS HC A20/MF A01 CSCL 22B

Control techniques for future large flexible spacecraft are developed. Control design and analysis are supported by a comprehensive CAD system. The proposed operational mobile communications satellite (OMSAT) featuring a 44 m offset fed antenna is used as target application. Requirements for satellite attitude control and communications beam pointing are defined. The following control methods are applied to the system: standard linear optimal regulator (LOR) with Luenberger observer, LOR/observer with selective spill-over suppression, frequency shaped LOR, LOR with closed-loop order reduction by cost decoupling, and robust servomechanism. E.A.K.

N85-31159*# Harris Government Aerospace Systems Div., Melbourne, Fla.
VIBRATION CONTROL EXPERIMENT DESIGN FOR THE 15-M HOOP/COLUMN ANTENNA
F. M. HAM and D. C. HYLAND *In* JPL Proc. of the Workshop on Identification and Control of Flexible Space Struct., Vol. 1 p 229-251 1 Apr. 1985 refs Sponsored by NASA. Langley Research Center
Avail: NTIS HC A20/MF A01 CSCL 22B

A test program is designed for a ground-based vibration control experiment utilizing as the test article the 15-M Hoop/Column Antenna. Overall objectives of the designed ground-based test program include: (1) the validation of large space structure (LSS) control systemm techniques; (2) the validation of LSS parameter identification techniques: (3) the evaluation of actuator of actuator and sensor placement methodology; and (3) the validation of LSS computer models. Critical concerns in LSS Controls and Dynamics are: low frequency vibrational modes, close modal spacing, parameter uncertainties, controller software limitations, nonlinearities and coupling of modes through damping. Analytical results are presented which include compensator designs for varying compensator order. Author

N85-31160*# Lockheed Missiles and Space Co., Palo Alto, Calif.
A HARDWARE DEMONSTRATION OF DISTRIBUTED CONTROL FOR A FLEXIBLE OFFSET-FEED ANTENNA
D. B. SCHAECHTER and N. C. NGUYEN (LMSC, Sunnyvale, Calif.) *In* JPL Proc. of the Workshop on Identification and Control of Flexible Space Struct., Vol. 1 p 253-268 1 Apr. 1985 refs
Avail: NTIS HC A20/MF A01 CSCL 22B

A fully instrumented hardware model of a flexible offset-feed antenna has been constructed for laboratory tests. Three rate gyros, four angular position laser sensors, and a set of ten distributed accelerometers are used to rconstruct the antenna state. Three control moment gyros are used to simultaneously orient the antenna, and to maintain a stable line of sight. A description is presented of the distributed antenna control system and experimental results. Author

N85-31161*# National Aeronautics and Space Administration, Washington, D.C.
CONTROL OF FLEXIBLE STRUCTURES
R. A. RUSSELL *In* JPL Proc. of the Workshop on Identification and Control of Flexible Space Struct., Vol. 1 p 269-297 1 Apr. 1985
Avail: NTIS HC A20/MF A01 CSCL 22B

The requirements for future space missions indicate that many of these spacecraft will be large, flexible, and in some applications, require precision geometries. A technology program that addresses the issues associated with the structure/control interactions for these classes of spacecraft is discussed. The goal of the NASA

control of flexible structures technology program is to generate a technology data base that will provide the designer with options and approaches to achieve spacecraft performance such as maintaining geometry and/or suppressing undesired spacecraft dynamics. This technology program will define the appropriate combination of analysis, ground testing, and flight testing required to validate the structural/controls analysis and design tools. This work was motivated by a recognition that large minimum weight space structures will be required for many future missions. The tools necessary to support such design included: (1) improved structural analysis; (2) modern control theory; (3) advanced modeling techniques; (4) system identification; and (5) the integration of structures and controls. B.W.

N85-31162*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.

SPACE STATION CONFIGURATION AND FLIGHT DYNAMICS IDENTIFICATION

E. METTER and M. H. MILMAN *In its* Proc. of the Workshop on Identification and Control of Flexible Space Struct., Vol. 1 p 299-343 1 Apr. 1985 refs

Avail: NTIS HC A20/MF A01 CSCL 22B

The Space Station will be assembled in low earth orbit by a combination of deployable and space erectable modules that are progressively integrated during successive flights of the Shuttle. The crew assisted space construction will result in a configuration which is a large scale composite of structural elements having connectivity with a wide range of possible end conditions and imprecisely known dynamic characteristics. The generic applications of Flight Dynamics Identification to the candidate Space Station configurations currently under consideration are described. Identification functions are categorized, and the various methods for extracting parameter estimates are correlated with the sensing of parameter estimates are correlated with the sensing of specific characteristics of interest to both engineering subsystems and users of the Station's commercial and scientific facilities. Onboard implementation architecture and constraints are discussed from the viewpoint of maximizing integration of the Identification process with the flight subsystem's data and signal flow. B.W.

N85-31163*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.

LARGE SPACE STRUCTURE FLIGHT EXPERIMENT

D. C. SCHWAB (LMSC, Sunnyvale, Calif.), S. J. WANG, and C. C. IH *In its* Proc. of the Workshop on Identification and Control of Flexible Space Struct., Vol. 1 p 345-381 1 Apr. 1985 refs

Avail: NTIS HC A20/MF A01 CSCL 22B

The primary purpose of this work is to provide a first order feasibility analysis of a large space structure flight experiment. The feasibility issues are addressed from the control technologist's point of view. Control and system identification techniques and algorithms are evaluated with a selected experiment antenna structure through analysis and computer simulation. The required and actuator hardware is assessed and its requirements examined with respect to the current state-of-the-art. The results of this study show that a shuttle attached flight experiment is feasible with moderate advancement of current control technology. The control and identification algorithms are well understood and can be adapted to the flight computers with additional dedicated processors. Although it is necessary to select a focused flight configuration to produce quantitative results, it is believed that, in general, performance requirements and capabilities, timelines, hardware, and algorithms are sufficiently generic in nature and can be applied to other configurations. Author

N85-31164*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

TIME-OPTIMAL BANG-BANG SLEW OF RIGIDIZED SCOLE CONFIGURATION

J. G. LIN (Northeastern Univ., Boston) and L. W. TAYLOR, JR. *In* JPL Proc. of the Workshop on Identification and Control of Flexible Space Struct., Vol. 1 p 383-399 1 Apr. 1985 refs (Contract NAG1-386)

Avail: NTIS HC A20/MF A01 CSCL 22B

This paper addresses: (1) an application of the well-known time-optimal bang-bang control theory to the design of minimal-time limited-torque single-axis slew maneuvers for the rigidized configuration of NASA Langley Research Center's Spacecraft Control Laboratory Experiment (SCOLE) and (2) the associated generic side effects due to spillover of slew motions and applied torques. Numerical experiments that helped pinpoint the specific causes of performance degradation are discussed. Analytical as well as scientifically interesting numerical research results are given. Author

N85-31165*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

EXPERIMENTS IN STRUCTURAL DYNAMICS AND CONTROL USING A GRID

R. C. MONTGOMERY *In* JPL Proc. of the Workshop on Identification and Control of Flexible Space Struct., Vol. 1 p401-412 1 Apr. 1985

Avail: NTIS HC A20/MF A01 CSCL 22B

Future spacecraft are being conceived that are highly flexible and of extreme size. The two features of flexibility and size pose new problems in control system design. Since large scale structures are not testable in ground based facilities, the decision on component placement must be made prior to full-scale tests on the spacecraft. Control law research is directed at solving problems of inadequate modelling knowledge prior to operation required to achieve peak performance. Another crucial problem addressed is accommodating failures in systems with smart components that are physically distributed on highly flexible structures. Parameter adaptive control is a method of promise that provides on-orbit tuning of the control system to improve performance by upgrading the mathematical model of the spacecraft during operation. Two specific questions are answered in this work. They are: What limits does on-line parameter identification with realistic sensors and actuators place on the ultimate achievable performance of a system in the highly flexible environment? Also, how well must the mathematical model used in on-board analytic redundancy be known and what are the reasonable expectations for advanced redundancy management schemes in the highly flexible and distributed component environment? B.W.

N85-31166*# California Univ., Los Angeles.

THE EXPERIMENTAL COMPUTER CONTROL OF A TWO-DIMENSIONAL HYPERBOLIC SYSTEM

Y. YAM, J. H. LANG (MIT, Cambridge), D. H. STAELIN (MIT, Cambridge), and T. L. JOHNSON (Bolt, Beranek and Newman, Inc., Cambridge, Mass.) *In* JPL Proc. of the Workshop on Identification and Control of Flexible Space Struct., Vol. 1 p 413-432 1 Apr. 1985 refs Sponsored in part by LMSC (Contract DAAG29-78-C-0020; AF-AFOSR-0318-83)

Avail: NTIS HC A20/MF A01 CSCL 22B

The experimental computer control of a two-dimensional hyperbolic system is described. The system consists of a 5-foot gold-coated rubber membrane mounted on a circular cylindrical drum. Seven electrodes reside on a command surface located behind the membrane inside the drum. These electrodes served as capacitive sensors and electrostatic force actuators of transverse membrane deflection. The membrane was modelled as flat, isotropic and uniformly tensioned. Transverse membrane deflections were expanded in normal modes. Controllers regulating membrane deflection are designed using aggregation and design procedures based upon sensor and actuator influence functions. The resulting control laws are implemented on a minicomputer in two sets of experiments. The experimental study confirms the

theoretically predicted behavior of the system, usefulness of the aggregation and design procedures, and the expectation that spillover can be made a beneficial source of damping in residual systems. B.W.

N85-31167*# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Oberpfaffenhofen (West Germany).
RATIONALE FOR AN EXPERIMENTAL TEST FOR FLEXIBLE SPACE STRUCTURE ATTITUDE CONTROL
T. LANGE, G. HEIMBOLD, B. SCHAEFER, and H. HOLZACH *In* JPL Proc. of the Workshop on Identification and Control of Flexible Space Struct., Vol. 1 p 433-445 1 Apr. 1985 refs Sponsored by ESA
Avail: NTIS HC A20/MF A01 CSCL 22B

The problems of large flexible spacecraft control are characterized by the infinite bandwidth of structural vibrations, which cannot be accounted for in the dynamic design model. This may lead to instability even, if ideal control hardware is assumed, which can be concluded from preceding numerical investigations. Additional performance limitations are expected to occur due to hardware constraints. A laboratory experiment is proposed to investigate the key problems in more detail. The test setup requirements being defined by the idealized control system are extremely high demanding a high speed processor and special hardware component developments. The test element is a wire suspended plate being controlled by an array processor via high performance sensors and actuators. First tests on component level indicate the feasibility of the system presently being developed. B.W.

N85-31168*# National Aerospace Lab., Tokyo (Japan).
NUMERICAL AND EXPERIMENTAL EVALUATION FOR SINGLE-AXIS CONTROL OF AN LSS LABORATORY MODEL
Y. OHKAMI, O. OKAMOTO, S. YOSHIMURA, T. KIDA, and I. YAMAGUCHI *In* JPL Proc. of the Workshop on Identification and Control of Flexible Space Struct., Vol. 1 p 447-462 1 Apr. 1985 refs
Avail: NTIS HC A20/MF A01 CSCL 22B

One of the major problems of LSS attitude control design stems from the modeling uncertainties due to modal truncation errors and modal parameter estimation errors. This modeling problem is investigated by evaluating poles and zeros of the frequency response functions, described in terms of constrained or unconstrained modes. The frequency domain approach is utilized to evaluated the results of modal analyses and direct output feedback controller experiments using a simple flexible spacecraft model consisting of a rigid primary body and flexible aluminum beam(s) with a control moment gyro as an actuator. The modal data are compared under the conditions that the model is constrained as the canti-lever and it is rotationally free on a single-axis air bearing table. In addition, the open-loop responses are experimentally examined under the impulsive disturbance to the appendage. The results of the control experiments show that the first vibration mode of the appendage and the interacted rotational motion of the primary body are damped in a short time as predicted by the numerical analysis, to produce damping ratio of 10-20%. Author

N85-31169*# Stanford Univ., Calif.
ON THE MEASUREMENT OF MATERIAL DAMPING IN A SIMULATED SPACE ENVIRONMENT
D. L. EDBERG *In* JPL Proc. of the Workshop on Identification and Control of Flexible Space Struct., Vol. 1 p 463-473 1 Apr. 1985 refs
(Contract AF-AFOSR-0062-82)
Avail: NTIS HC A20/MF A01 CSCL 22B

A new, experimental method of measuring the material damping of test models is presented. The method involves measuring the decay of free vibrations as the model is lofted into free-fall in a vacuum. Vibration signals are transmitted through the vacuum by a miniature telemetry system. The resulting data are recorded and later analyzed using a fast Fourier transform technique to determine the percent critical damping. The experimental apparatus offers a unique means to reset the experiment without breaking the vacuum, which reduces the time between runs. Author

N85-31170*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
PROCEEDINGS OF THE WORKSHOP ON IDENTIFICATION AND CONTROL OF FLEXIBLE SPACE STRUCTURES, VOLUME 2
G. RODRIGUEZ, ed. 1 Apr. 1985 449 p refs Workshop held in San Diego, Calif., 4-6 Jul. 1984; sponsored in cooperation with JPL and NASA. Langley Research Center 3 Vol.
(Contract NAS7-918)
(NASA-CR-176052; JPL-PUB-85-29-VOL-2; NAS 1.26:176052)
Avail: NTIS HC A19/MF A01 CSCL 22B

The results of a workshop on identification and control of flexible space structures held in San Diego, CA, July 4 to 6, 1984 are discussed. The main objectives of the workshop were to provide a forum to exchange ideas in exploring the most advanced modeling, estimation, identification and control methodologies to flexible space structures. The workshop responded to the rapidly growing interest within NASA in large space systems (space station, platforms, antennas, flight experiments) currently under design. Dynamic structural analysis, control theory, structural vibration and stability, and distributed parameter systems are discussed.

N85-31171*# British Columbia Univ., Vancouver.
VIBRATION/LIBRATION INTERACTION DYNAMICS DURING THE ORBITER BASED DEPLOYMENT OF FLEXIBLE MEMBERS
V. J. MODI and A. M. IBRAHIM *In* JPL Proc. of the Workshop on Identification and Control of Flexible Space Struct., Vol. 2 p 7-22 1 Apr. 1985 refs
Avail: NTIS HC A19/MF A01 CSCL 22B

Essential features of a general formulation for studying librational dynamics of a large class of spacecraft during deployment of flexible members are reviewed. The formulation is applicable to a variety of missions ranging from deployment of antennas, booms and solar panels to manufacturing of trusses for space platforms using the space shuttle. The governing nonlinear, non-autonomous and coupled equations of motion are extremely difficult to solve even with the help of a computer, not to mention the cost involved. To get some appreciation as to the complex interactions between flexibility, deployment and attitude dynamics as well as to help pursue stability and control analysis, the equations are linearized about their nominal deflected equilibrium configuration. The procedure is applied to the Space Shuttle based deployment of boom and plate-like members. Results suggest substantial influence of the inertia parameter, flexural rigidity of the appendages, orbit eccentricity, deployment velocity, initial conditions, etc. on the system response. The results should prove useful in planning of the Orbiter based experiments aimed at assessing effectiveness of procedures for studying dynamics and control of flexible orbiting members. Author

N85-31172*# Washington Univ., Seattle.
DESIGN OF MULTIVARIABLE CONTROLLERS USING THE INTEGRATED ANALYSIS CAPABILITY (IAC)
J. A. BOSSI, G. A. PRICE (Boeing Aerospace Co., Seattle), and S. A. WAINKLEBLACK (Boeing Aerospace Co., Seattle) *In* JPL Proc. of the Workshop on Identification and Control of Flexible Space Struct., Vol. 2 p 23-37 1 Apr. 1985 refs
Avail: NTIS HC A19/MF A01 CSCL 22B

Dynamic analysis and controls design for flexible spacecraft involves high-order dynamic systems with multiple inputs and outputs. Computer tools are essential for such analysis. The controls/structures interaction analysis capability of an inter-disciplinary computer software system, called the Integrated Analysis Capability (IAC), is described. An overview of IAC components and procedures is presented, and an example of a preliminary space station controls design is shown. R.J.F.

N85-31173*# Structural Dynamics Research Corp., San Diego, Calif.

A STRUCTURAL DYNAMICS APPROACH TO THE SIMULATION OF SPACECRAFT CONTROL/STRUCTURE INTERACTION

J. W. YOUNG *In* JPL Proc. of the Workshop on Identification and Control of Flexible Space Struct., Vol. 2 p 39-60 1 Apr. 1985 refs

Avail: NTIS HC A19/MF A01 CSCL 22B

A relatively simple approach to the analysis of linear spacecraft control/structure interaction problems is presented. The approach uses a commercially available structural system dynamic analysis package for both controller and plant dynamics, thus obviating the need to transfer data between separate programs. The unilateral coupling between components in the control system block diagram is simulated using sparse matrix stiffness and damping elements available in the structural dynamic code. The approach is illustrated with a series of simple tutorial examples of a rigid spacecraft core with flexible appendages. Author

N85-31174*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.

ATTITUDE CONTROL TRADEOFF STUDY BETWEEN THE USE OF A FLEXIBLE BEAM AND A TETHER CONFIGURATION FOR THE CONNECTION OF TWO BODIES IN ORBIT

S. H. GRAFF *In its* Proc. of the Workshop on Identification and Control of Flexible Space Struct., Vol. 2 p 61-82 1 Apr. 1985 refs

Avail: NTIS HC A19/MF A01 CSCL 22B

Sometimes it is necessary to mount a payload remotely from the main body of a spacecraft or space station. The reasons for this vary from vibration isolation to avoidance of measurement contamination. For example the SP-100 project, which grew out of the increased interest in nuclear power in space for space stations and for deep space explorations, requires separation of the nuclear reactor from the user because of vibration, heat and radiation. The different attitude control problems for beam and tether configurations are discussed. The beam configuration uses a conservative design approach. The vibration, beam flexibility and deployment concerns are analyzed. The tether configuration offers some very attractive design features, but not without several thorny problems. These problems are analyzed. One configuration will be recommended for the main thrust of the SP-100 design effort based on attitude control considerations. R.J.F.

N85-31175*# College de France, Paris.

SOME ASYMPTOTIC PROBLEMS IN THE OPTIMAL CONTROL OF DISTRIBUTED SYSTEMS

J. L. LIONS *In* JPL Proc. of the Workshop on Identification and Control of Flexible Space Struct., Vol. 2 p 83-100 1 Apr. 1985 refs

Avail: NTIS HC A19/MF A01 CSCL 22B

The optimal control of structures which consist of composite materials or of perforated materials is discussed. Asymptotic formula, derived from the so-called homogenization theory, are presented which allow the replacement of very complicated problems by much simpler ones. R.J.F.

N85-31176*# State Univ. of New York, Buffalo.

FINITE CONTROL IN UNDERDAMPED DISTRIBUTED PARAMETER SYSTEMS

D. J. INMAN *In* JPL Proc. of the Workshop on Identification and Control of Flexible Space Struct., Vol. 2 p 101-109 1 Apr. 1985 refs

(Contract AF-AFOSR-0242-82)

Avail: NTIS HC A19/MF A01 CSCL 22B

Specifically, a class of distributed parameter systems is defined using Hilbert space methods based on a partial differential equation model of a structure. In this space a simple, easy to check definition of underdamping is constructed based on the well known single degree of freedom concept of critical damping. It is then shown that if a given distributed parameter system satisfies this definition, each mode of the modal expansion of the solution is in fact an underdamped function of time. It is noted that a distributed parameter system which is underdamped is also uniformly exponentially stable. By appealing to the work of Gibson, a finite dimensional model of the system will yield satisfactory control laws. Furthermore, it is shown that the assumption of the underdamping also allows straightforward computation of rough bounds on the magnitude of the unmodeled or residual modes for a modal truncation scheme. Hence, underdamped systems are precisely that class of distributed parameter systems which are not likely to have spillover problems and which will yield convergence of finite dimensional control laws to control laws which are optimal for the full distributed parameter model of the system. R.J.F.

N85-31177*# Rensselaer Polytechnic Inst., Troy, N.Y.

NEW DIRECTIONS IN ASYMPTOTICALLY STABLE FINITE-DIMENSIONAL ADAPTIVE CONTROL OF LINEAR DISTRIBUTED PARAMETER SYSTEMS

M. J. BALAS *In* JPL Proc. of the Workshop on Identification and Control of Flexible Space Struct., Vol. 2 p 111-131 1 Apr. 1985 refs

(Contract NAG1-171; NSF ECS-80-16173; AF-AFOSR-0124-83)

Avail: NTIS HC A19/MF A01 CSCL 22B

Distributed Parameter Systems (DPS), such as systems described by partial differential equations, require infinite-dimensional state space descriptions to correctly model their dynamical behavior. However, any adaptive control algorithm must be finite-dimensional in order to be implemented via on-line digital computers. Finite-dimensional adaptive control of linear DPS requires stability analysis of nonlinear, time-varying, infinite-dimensional systems. The structure of nonadaptive finite-dimensional control of linear DPS is summarized as it relates to the existence of limiting systems for adaptive control. Two candidate schemes for finite-dimensional adaptive control of DPS are described and critical issues in infinite-dimensional stability analysis are discussed, in particular, the invariance principle, center manifold theory, and relationships between input-output and internal stability. Author

N85-31178*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.

A FACTORIZATION APPROACH TO THE LINEAR REGULATOR QUADRATIC COST PROBLEM

M. H. MILMAN *In its* Proc. of the Workshop on Identification and Control of Flexible Space Struct., Vol. 2 p 133-144 1 Apr. 1985 refs

Avail: NTIS HC A19/MF A01 CSCL 05A

A factorization approach to the linear regulator quadratic cost problem is developed. This approach makes some new connections between optimal control, factorization, Riccati equations and certain Wiener-Hopf operator equations. Applications of the theory to systems describable by evolution equations in Hilbert space and differential delay equations in Euclidean space are presented. Author

N85-31181*# *California Univ., Los Angeles.*

APPROXIMATION OF OPTIMAL INFINITE DIMENSIONAL COMPENSATORS FOR FLEXIBLE STRUCTURES

J. S. GIBSON, D. L. MINGORI, A. ADAMIAN, and F. JABBARI *In* JPL Proc. of the Workshop on Identification and Control of Flexible Space Struct., Vol. 2 p 201-218 1 Apr. 1985 refs

Avail: NTIS HC A19/MF A01 CSCL 22B

The infinite dimensional compensator for a large class of flexible structures, modeled as distributed systems are discussed, as well as an approximation scheme for designing finite dimensional compensators to approximate the infinite dimensional compensator. The approximation scheme is applied to develop a compensator for a space antenna model based on wrap-rib antennas being built currently. While the present model has been simplified, it retains the salient features of rigid body modes and several distributed components of different characteristics. The control and estimator gains are represented by functional gains, which provide graphical representations of the control and estimator laws. These functional gains also indicate the convergence of the finite

dimensional compensators and show which modes the optimal compensator ignores. R.J.F.

N85-31182*# California Univ., Los Angeles.
CONTROL OF A FLEXIBLE SPACE ANTENNA: A FINITE DIMENSIONAL PERSPECTIVE BASED ON DISTRIBUTED PARAMETER THEORY
D. L. MINGORI, J. S. GIBSON, P. BLELLOCH, and A. ADAMIAN *In* JPL Proc. of the Workshop on Identification and Control of Flexible Space Struct., Vol. 2 p 219-229 1 Apr. 1985 refs
Avail: NTIS HC A19/MF A01 CSCL 22B

The methods presented are based on results from infinite dimensional control theory, but they can be described and used in a finite dimensional context. This blend leads to an approach which employs powerful ideas on convergence, and is also quite practical for systems of realistic complexity. Appropriate reduced order models are generated simultaneously with the development of the compensator. The required models change as a function of changes in the performance demanded, sensor and actuator location, inherent damping, disturbances, etc. Thus they are driven by the control and estimation problems at hand. The compensators which emerge are very close to the ideal compensators which would be obtained with a very large order model. However, some simplification is frequently possible. The method of balanced realizations was found to be effective for this purpose. R.J.F.

N85-31183*# Draper (Charles Stark) Lab., Inc., Cambridge, Mass.
AN INTEGRATED CONTROL AND MINIMUM MASS STRUCTURAL OPTIMIZATION ALGORITHM FOR LARGE SPACE STRUCTURES
A. MESSAC, J. TURNER (Cambridge Research, Belmont, Mass.), and K. SOOSAAR (Cambridge Research, Belmont, Mass.) *In* JPL Proc. of the Workshop on Identification and Control of Flexible Space Struct., Vol. 2 p 231-266 1 Apr. 1985 refs
Avail: NTIS HC A19/MF A01 CSCL 22B

A new approach is discussed for solving dual structural control optimization problems for high-order flexible space structures, where reduced-order structural models are employed and minimum mass designs are sought. For a given initial structural design, a quadratic control cost is minimized subject to a constant-mass constraint. The sensitivity of the optimal control cost with respect to the structural design variables is then determined and used to obtain successive structural redesigns, using a constrained gradient optimization algorithm. This process is repeated until the constrained control cost sensitivity becomes negligible. The minimum mass design is obtained by solving a sequence of neighboring optimal constant mass designs, where the sequence of optimal performance indices has a minimum at the optimal minimum mass design. A numerical example is presented which demonstrates that this new approach effectively addresses the problem of dual optimization for potentially very high-order structures. R.J.F.

N85-31185*# Aerospace Corp., Los Angeles, Calif.
ISAAC (INTEGRATED STRUCTURAL ANALYSIS AND CONTROL) VIA CONTINUUM MODELING AND DISTRIBUTED FREQUENCY DOMAIN DESIGN TECHNIQUES
C. L. GUSTAFSON, M. ASWANI, A. L. DORAN, and G. T. TSENG *In* JPL Proc. of the Workshop on Identification and Control of Flexible Space Struct., Vol. 2 p 287-310 1 Apr. 1985 refs Sponsored in part by AFOSR
Avail: NTIS HC A19/MF A01 CSCL 22B

A methodology is proposed for the integrated design of structures and their controls. The integration of design is accomplished through simultaneous selection, via optimization, of designer-specified parameters governing the structure and its controller. The cost function is chosen to address the primary structural and control goals. Inequality constraints are added to insure that additional design requirements are met. The methodology is illustrated through development of an example involving a cantilever beam. A distributed transfer function is derived from the Bernoulli-Euler beam equation. A controller parameterization is then chosen, and performance requirements specified. A controller is then obtained via optimization, which is shown to give good performance. R.J.F.

N85-31186*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
OPTIMIZATION OF CONTROLLED STRUCTURES
M. SALAMA, M. HAMIDI, and L. DEMSETZ *In its* Proc. of the Workshop on Identification and Control of Flexible Space Struct., Vol. 2 p 311-327 1 Apr. 1985 refs Sponsored by AFWAL
Avail: NTIS HC A19/MF A01 CSCL 22B

A formulation is presented for the coupled optimal design of a structural system and its control by defining a composite objective function as a linear combination of two components: a structural objective and a control objective. For the case when the structural objective is a function of the structural design variables only, and when the control objective is represented by the quadratic functional of the response and control energy, one can analytically express the optimal control in terms of any set of admissible structural design variables. The expression for the optimal control is used recursively in an iterative Newton-Raphson search scheme, the goal of which is to determine a corresponding optimal set of structural design variables that minimize the composite objective function. A numerical example is given to illustrate the computational procedure. Author

N85-31187*# Cornell Univ., Ithaca, N.Y. Dept. of Theoretical and Applied Mechanics.
PARAMETRIC STIFFNESS CONTROL OF FLEXIBLE STRUCTURES
F. C. MOON and R. H. RAND *In* JPL Proc. of the Workshop on Identification and Control of Flexible Space Struct., Vol. 2 p 329-342 1 Apr. 1985 refs Sponsored by AFOSR
Avail: NTIS HC A19/MF A01 CSCL 22B

An unconventional method for control of flexible space structures using feedback control of certain elements of the stiffness matrix is discussed. The advantage of using this method of configuration control is that it can be accomplished in practical structures by changing the initial stress state in the structure. The initial stress state can be controlled hydraulically or by cables. The method leads, however, to nonlinear control equations. In particular, a long slender truss structure under cable induced initial compression is examined. both analytical and numerical analyses are presented. Nonlinear analysis using center manifold theory and normal form theory is used to determine criteria on the nonlinear control gains for stable or unstable operation. The analysis is made possible by the use of the exact computer algebra system MACSYMA. R.J.F.

N85-31188*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
VIBRATIONAL STABILIZATION OF FLEXIBLE STRUCTURES
M. ZAK *In its* Proc. of the Workshop on Identification and Control of Flexible Space Struct., Vol. 2 p 343-349 1 Apr. 1985 refs
Avail: NTIS HC A19/MF A01 CSCL 22B

It has been demonstrated that a high frequency excitation (HFE) field significantly changes the fundamental properties of mechanical systems. The most important contribution of HFE is the stiffening effect of an elastic continuum in the direction of the wave vector. This effect allows control of stiffness in any selected direction by the corresponding changes in the intensity of HFE. This new approach can be effective for large flexible space structures. Such an approach may prove to be very practical in the sense that large structures need to be made as flimsy as possible for low cost under ordinary situations. However, for certain operations such as development, orbital transfer, docking, and other circumstances, it would be vital to have a means of temporarily stiffening certain structural members. If the structure was designed to meet these occasional loads without temporary stiffening, it would be considerably more massive and more expensive. R.J.F.

N85-31189*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
STIFFNESS CONTROL OF LARGE SPACE STRUCTURES
J. L. FANSON (California Inst. of Tech., Pasadena), J. CHEN, and T. K. CAUGHEY (California Inst. of Tech., Pasadena) *In its* Proc. of the Workshop on Identification and Control of Flexible Space Struct., Vol. 2 p 351-364 1 Apr. 1985 refs
Avail: NTIS HC A19/MF A01 CSCL 22B

A technique for using internal force producing dual element/actuators for vibration suppression of large space structures is proposed. The method is applied to a low order system. Selective modal damping is achieved. The actuators used in this method may be electrically powered. The method is suitable for structures which are too slender or flimsy to permit the use of reaction jet-type actuators. Author

N85-31190*# University of Southern California, Los Angeles.
SUB-OPTIMAL CONTROL OF NONLINEAR FLEXIBLE SPACE STRUCTURES
T. J. DEHGHANYAR, S. F. MASRI, R. K. MILLER, G. A. BEKEY, and T. K. CAUGHEY (California Inst. of Tech., Pasadena) *In* JPL Proc. of the Workshop on Identification and Control of Flexible Space Struct., Vol. 2 p 365-380 1 Apr. 1985 refs Sponsored by NSF
Avail: NTIS HC A19/MF A01 CSCL 22B

A simple yet effective method is presented for the on-line vibration control of nonlinear distributed parameter systems, with constant or time-varying properties, responding to a wide class of dynamic environments. The control procedure uses pulse generators located at selected positions throughout a given system. The degree of system oscillation near each controller determines the controller's activation time and pulse amplitude. The direct method of Liapunov is used to establish that the response of the controlled nonlinear system is Lagrange stable. Analytical and experimental studies of a wing-like plate demonstrate the feasibility, reliability, and robustness of the proposed vibration-suppression method. Author

N85-31191*# New Mexico Univ., Albuquerque.
AN OVERVIEW OF LATEST MODEL REDUCTION AND CONTROL METHODS OF LARGE FLEXIBLE SPACE STRUCTURES
J. M. SANTIAGO, W. J. LANGE, JR. (AFWL), and M. JAMSHIDI *In* JPL Proc. of the Workshop on Identification and Control of Flexible Space Struct., Vol. 2 p 381-395 1 Apr. 1985 refs
Avail: NTIS HC A19/MF A01 CSCL 22B

The latest trends and theoretical developments involved with the modeling and control of Large Flexible Space Structures (LFSS) are described. The paper addresses first the basic problems, characteristics, and difficulties inherent in modeling and control of LFSS. Major sources of difficulties and errors are the stiffness and damping operators of the dynamic model. Extensions of Linear Quadratic Gaussian (LQG) theory as applied to LFSS are presented, including frequency-shaped cost functionals and perturbation methods. The minimum data/maximum entropy approach which uses a stochastic design model to overcome difficulties found in the LQG-based methods is described. Latest trends in system theory including balanced realization and singular-value analysis are used to determine reduced order controllers and models. Ad hoc methods such as component cost analysis and modal cost analysis are discussed in context with the closed-loop reduction problem of controller order versus performance. The minimum data/maximum entropy approach also addresses controller order versus performance. Those areas of control science and large scale systems that appear to have an important role in understanding and solving LFSS modeling and control are also identified. Author

N85-31192*# General Electric Co., Philadelphia, Pa. Space Div.
FREQUENCY DOMAIN CONTROL DESIGN OF LARGE SPACE STRUCTURES: A PRACTICAL APPROACH
R. HARDING and A. DAS *In* JPL Proc. of the Workshop on Identification and Control of Flexible Space Struct., Vol. 2 p 397-414 1 Apr. 1985 refs
Avail: NTIS HC A19/MF A01 CSCL 22B

Requirements indicate the need for much larger, more accurate, and in some cases, very dynamic satellites. Large control system bandwidths are needed to meet accuracy and response requirements while maintaining tight control over appendage oscillations. Studies in recent years have shown that linear quadratic Gaussian (LQG) controllers can achieve the desired performance if the system is linearized and if the system model is accurate. Results of an LQG controller applied to a single axis satellite with large solar arrays, are given. A reduced order model (ROM) comprises rigid body motion with dominant structural modes. Optimal control and estimation gains are calculated based on an extremely conservative 0.0005 critical damping ratio. In order to examine stability characteristics, single-input single-output (SISO) frequency response concepts are generalized to develop a method of displaying open loop frequency response of multi-input multi-output (MIMO) control system. Author

N85-31193*# Dornier-Werke G.m.b.H., Friedrichshafen (West Germany).
A CONTROL CONCEPT FOR LARGE FLEXIBLE SPACECRAFT USING ORDER REDUCTION TECHNIQUES
G. THIEME and H. ROTH *In* JPL Proc. of the Workshop on Identification and Control of Flexible Space Struct., Vol. 2 p 415-432 1 Apr. 1985 refs Sponsored by ESA
Avail: NTIS HC A19/MF A01 CSCL 22B

Results found during the investigation of control problems of large flexible spacecraft are given. A triple plate configuration of such a spacecraft is defined and studied. The model is defined by modal data derived from infinite element modeling. The order reduction method applied is briefly described. An attitude control concept with low and high authority control has been developed to design an attitude controller for the reduced model. The stability and response of the original system together with the reduced controller is analyzed. Author

N85-31194*# Draper (Charles Stark) Lab., Inc., Cambridge, Mass.
WIDEBAND DISTURBANCE ACCOMMODATION IN PRECISION FLEXIBLE SPACE STRUCTURES
D. R. HEGG and G. J. KISSEL (MIT, Cambridge) *In* JPL Proc. of the Workshop on Identification and Control of Flexible Space Struct., Vol. 2 p 433-448 1 Apr. 1985 refs
(Contract F30602-81-C-0180)
Avail: NTIS HC A19/MF A01 CSCL 22B

Numerous spacecraft missions currently being formulated exhibit several basic and sharply conflicting features: selected components (e.g., an optical train) of inherently flexible structures are to maintain precision pointing performance in a wideband disturbance environment. Within the overall process of synthesizing an active controller to deal with this difficult problem, the aspects of reduced-order modelling and of actuator and sensor selection are crucial to the successful implementation of any controller feedback strategy. The principal focus in this paper is on the influence of actuator and sensor selection upon the effectiveness of a specified controller strategy for wideband disturbance accommodation. A genetic optical support structure is used for a number of design examples. Active transducer selections are made systematically based upon their direct contributuion to optical pointing error. Controller designs incorporating the various transducer selections exhibit stability in the presence of unmodeled modes over a frequency range substantially beyond the bandwidth of the disturbance. Author

N85-31195*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
PROCEEDINGS OF THE WORKSHOP ON IDENTIFICATION AND CONTROL OF FLEXIBLE SPACE STRUCTURES, VOLUME 3
G. RODRIGUEZ, ed. 1 Apr. 1985 463 p refs Workshop held in San Diego, Calif., 4-6 Jul. 1984; sponsored in cooperation with JPL and NASA. Langley Research Center 3 Vol.
(Contract NAS7-918)
(NASA-CR-176053; JPL-PUB-85-29-VOL-3; NAS 1.26:176053)
Avail: NTIS HC A20/MF A01 CSCL 22B

The results of a workshop on identification and control of flexible space structures are reported. This volume deals mainly with control theory and methodologies as they apply to space stations and large antennas. Integration and dynamics and control experimental findings are reported. Among the areas of control theory discussed were feedback, optimization, and parameter identification.

N85-31196*# Toronto Univ. (Ontario).
A STUDY ON THE CONTROL OF THIRD GENERATION SPACECRAFT
E. J. DAVISON and W. GESING *In* JPL Proc. of the Workshop on Identification and Control of Flexible Space Struct., Vol. 3 p 1-19 1 Apr. 1985 refs Sponsored in part by Dept. of Communications
Avail: NTIS HC A20/MF A01 CSCL 22B

An overview of some studies which have recently been carried out on the control of third generation spcecraft, as modelled by the MSAT space vehicle configuration, is made. This spacecraft is highly nonsymmetrical and has appendages which cannot in general be assumed to be rigid. In particular, it is desired to design a controller for MSAT which stabilizes the system and satisfies certain attitude control, shape control, and possibly stationkeeping requirements; in addition, it is desired that the resultant controller should be robust and avoid any undesirable spill over effects. In addition, the controller obtained should have minimum complexity. The method of solution adopted to solve this class of problems is to formulate the problem as a robust servomechanism problem, and thence to obtain existence conditions and a controller characterization to solve the problem. The final controller obtained for MSAT has a distributed control configuration and appears to be quite satisfactory. Author

N85-31197*# Air Force Academy, Colo.
SENSOR/ACTUATOR SELECTION FOR THE CONSTRAINED VARIANCE CONTROL PROBLEM
M. L. DELORENZO and R. E. SKELTON (Purdue Univ., Lafayette, Ind.) *In* JPL Proc. of the Workshop on Identification and Control of Flexible Space Struct., Vol. 3 p 21-36 1 Apr. 1985 refs
Avail: NTIS HC A20/MF A01 CSCL 22B

The problem of designing a linear controller for systems subject to inequality variance constraints is considered. A quadratic penalty function approach is used to yield a linear controller. Both the weights in the quadratic penalty function and the locations of sensors and actuators are selected by successive approximations to obtain an optimal design which satisfies the input/output variance constraints. The method is applied to NASA's 64 meter Hoop-Column Space Antenna for satellite communications. In addition the solution for the control law, the main feature of these results is the systematic determination of actuator design requirements which allow the given input/output performance constraints to be satisfied. Author

N85-31198*# State Univ. of New York, Buffalo.
EIGENVALUE PLACEMENT AND STABILIZATION BY CONSTRAINED OPTIMIZATION
S. M. DECARO (AT and T Bell Labs, Whippany, N.J.) and D. J. INMAN *In* JPL Proc. of the Workshop on Identification and Control of Flexible Space Struct., Vol. 3 p 37-46 1 Apr. 1985 refs
(Contract AF-AFOSR-0242-82)
Avail: NTIS HC A20/MF A01 CSCL 22B

A pole placement algorithm is proposed which uses constrained nonlinear optimization techniques on a finite dimensional model of a linear n degree of freedom system. Low order feedback control is assumed where r poles may be assigned; r being the rank of the sensor coefficient matrix. It is shown that by combining feedback control theory methods with optimization techniques, one can ensure the stability characteristics of a system, and can alter its transient response. Author

N85-31199*# Aerospace Corp., Los Angeles, Calif.
MATRIX TRANSFER FUNCTION DESIGN FOR FLEXIBLE STRUCTURES: AN APPLICATION
T. J. BRENNAN, A. V. COMPITO, A. L. DORAN, C. L. GUSTAFSON, and C. L. WONG *In* JPL Proc. of the Workshop on Identification and Control of Flexible Space Struct., Vol. 3 p 47-62 1 Apr. 1985 refs
Avail: NTIS HC A20/MF A01 CSCL 22B

The application of matrix transfer function design techniques to the problem of disturbance rejection on a flexible space structure is demonstrated. The design approach is based on parameterizing a class of stabilizing compensators for the plant and formulating the design specifications as a constrained minimization problem in terms of these parameters. The solution yields a matrix transfer function representation of the compensator. A state space realization of the compensator is constructed to investigate performance and stability on the nominal and perturbed models. The application is made to the ACOSSA (Active Control of Space Structures) optical structure. Author

N85-31200*# McDonnell-Douglas Technical Services Co., Inc., Houston, Tex.
ROBUST CONTROL DESIGN FOR LARGE SPACE STRUCTURES
W. L. EASTMAN and J. A. BOSSI (Washington Univ.) *In* JPL Proc. of the Workshop on Identification and Control of Flexible Space Struct., Vol. 3 p 63-82 1 Apr. 1985 refs
Avail: NTIS HC A20/MF A01 CSCL 22B

The control design problem for the class of future spacecraft referred to as large space structures (LSS) is by now well known. The issue is the reduced order control of a very high order, lightly damped system with uncertain system parameters, particularly in the high frequency modes. A design methodology which incorporates robustness considerations as part of the design process is presented. Combining pertinent results from multivariable systems theory and optimal control and estimation, LQG eigenstructure assignment and LQG frequency shaping, were used to improve singular value robustness measures in the presence of control and observation spillover. G.L.C.

N85-31201*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
ON THE STABILITY OF COLLOCATED CONTROLLERS IN THE PRESENCE OR UNCERTAIN NONLINEARITIES AND OTHER PERILS
S. M. JOSHI *In* JPL Proc. of the Workship on Identification and Control of Flexible Space Struct., Vol. 3 p 83-98 1 Apr. 1985 refs
Avail: NTIS HC A20/MF A01 CSCL 22B

Robustness properties are investigated for two types of controllers for large flexible space structures, which use collocated sensors and actuators. The first type is an attitude controller which uses negative definite feedback of measured attitude and rate, while the second type is a damping enhancement controller which uses only velocity (rate) feedback. It is proved that collocated attitude controllers preserve closed loop global asymptotic stability when linear actuator/sensor dynamics satisfying certain phase conditions are present, or monotonic increasing nonlinearities are present. For velocity feedback controllers, the global asymptotic stability is proved under much weaker conditions. In particular, they have 90 phase margin and can tolerate nonlinearities belonging to the (0,infinity) sector in the actuator/sensor characteristics. The results significantly enhance the viability of both types of collocated controllers, especially when the available information about the large space structure (LSS) parameters is inadequate or inaccurate. Author

N85-31202*# Centre National de la Recherche Scientifique, Saint Martin d'Heres (France).
ADAPTIVE CONTROL: ACTUAL STATUS AND TRENDS
I. D. LANDAU *In* JPL Proc. of the Workshop on Identification and Control of Flexible Space Struct., Vol. 3 p 99-115 1 Apr. 1985 refs
Avail: NTIS HC A20/MF A01 CSCL 22B

Important progress in research and application of Adaptive Control Systems has been achieved in the last ten years. The techniques which are currently used in applications will be reviewed. Theoretical aspects currently under investigation and which are related to the application of adaptive control techniques in various fields will be briefly discussed. Applications in various areas will be briefly reviewed. The use of adaptive techniques for vibrations *monitoring and active vibration control will be emphasized.*
Author

N85-31203*# City Coll. of the City Univ. of New York.
A NONLINEAR DUAL-ADAPTIVE CONTROL STRATEGY FOR IDENTIFICATION AND CONTROL OF FLEXIBLE STRUCTURES
F. E. THAU *In* JPL Proc. of the Workshop on Identification and Control of Flexible Space Struct., Vol. 3 p 117-125 1 Apr. 1985 refs
(Contract NAG1-6)
Avail: NTIS HC A20/MF A01 CSCL 22B

A technique is presented for obtaining a control law to regulate the modal dynamics and identify the modal parameters of a flexible structure. The method is based on using a min-max performance index to derive a control law which may be considered to be a best compromise between optimum one step control and identification inputs. Features of the approach are demonstrated by a computer simulation of the controlled modal response of a flexible beam.
Author

N85-31204*# Rensselaer Polytechnic Inst., Troy, N.Y.
STABLE DIRECT ADAPTIVE CONTROL OF LINEAR INFINITE-DIMENSIONAL SYSTEMS USING A COMMAND GENERATOR TRACKER APPROACH
M. J. BALAS, H. KAUFMAN, and J. WEN *In* JPL Proc. of the Workshop on Identification and Control of Flexible Space Struct., Vol. 3 p 127-144 1 Apr. 1985 refs
(Contract AF-AFOSR-0124-83; NSF ECS-80-16173)
Avail: NTIS HC A20/MF A01 CSCL 22B

A command generator tracker approach to model following contol of linear distributed parameter systems (DPS) whose *dynamics are described on infinite dimensional Hilbert spaces is* presented. This method generates finite dimensional controllers capable of exponentially stable tracking of the reference trajectories when certain ideal trajectories are known to exist for the open loop DPS; we present conditions for the existence of these ideal trajectories. An adaptive version of this type of controller is also presented and shown to achieve (in some cases, asymptotically) *stable finite dimensional control of the infinite dimensional DPS.*
Author

N85-31205*# Stanford Univ., Calif.
SELF-TUNING ADAPTIVE-CONTROLLER USING ONLINE FREQUENCY IDENTIFICATION
W. W. CHIANG and R. H. CANNON, JR. *In* JPL Proc. of the Workshop on Identification and Control of Flexible Space Struct., Vol. 3 p 145-160 1 Apr. 1985 refs Sponsored in part by NASA Langley Research Center
Avail: NTIS HC A20/MF A01 CSCL 22B

A real time adaptive controller was designed and tested successfully on a fourth order laboratory dynamic system which features very low structural damping and a noncolocated actuator sensor pair. The controller, implemented in a digital minicomputer, consists of a state estimator, a set of state feedback gains, and a frequency locked loop (FLL) for real time parameter identification. The FLL can detect the closed loop natural frequency of the system being controlled, calculate the mismatch between a plant parameter and its counterpart in the state estimator, and correct the estimator parameter in real time. The adaptation algorithm *can correct the controller error and stabilize the system for more* than 50% variation in the plant natural frequency, compared with a 10% stability margin in frequency variation for a fixed gain controller having the same performance at the nominal plant condition. After it has locked to the correct plant frequency, the adaptive controller works as well as the fixed gain controller does when there is no parameter mismatch. The very rapid convergence *of this adaptive system is demonstrated experimentally, and can* also be proven with simple root locus methods.
Author

N85-31206*# Lockheed Missiles and Space Co., Palo Alto, Calif.
ADAPTIVE FILTERING FOR LARGE SPACE STRUCTURES: A CLOSED-FORM SOLUTION
H. E. RAUCH and D. B. SCHAECHTER *In* JPL Proc. of the Workshop on Identification and Control of Flexible Space Struct., Vol. 3 p 161-173 1 Apr. 1985 refs
Avail: NTIS HC A20/MF A01 CSCL 22B

In a previous paper Schaechter proposes using an extended Kalman filter to estimate adaptively the (slowly varying) frequencies and damping ratios of a large space structure. The time varying gains for estimating the frequencies and damping ratios can be determined in closed form so it is not necessary to integrate the matrix Riccati equations. After certain approximations, the time varying adaptive gain can be written as the product of a constant matrix times a matrix derived from the components of the estimated state vector. This is an important savings of computer resources and allows the adaptive filter to be implemented with approximately the same effort as the nonadaptive filter. The success of this new approach for adaptive filtering was demonstrated using synthetic data from a two mode system.
Author

N85-31207*# Yale Univ., New Haven, Conn.
ROBUST ADAPTIVE CONTROL
K. S. NARENDRA and A. M. ANNASWAMY *In* JPL Proc. of the Workshop on Identification and Control of Flexible Space Struct., Vol. 3 p 175-195 1 Apr. 1985 refs
(Contract NSF ECS-83-00223)
Avail: NTIS HC A10/MF A01 CSCL 22B

Several concepts and results in robust adaptive control are are discussed and is organized in three parts. The first part surveys existing algorithms. Different formulations of the problem and theoretical solutions that have been suggested are reviewed here. The second part contains new results related to the role of persistent excitation in robust adaptive systems and the use of hybrid control to improve robustness. In the third part promising new areas for future research are suggested which combine different approaches currently known.
Author

N85-31209*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
OPTIMAL SENSOR LOCATIONS FOR STRUCTURAL IDENTIFICATION
F. E. UDWADIA (Univ. of Southern California, Los Angeles) and J. GARBA *In its* Proc. of the Workshop on Identification and Control of Flexible Space Struct., Vol. 3 p 247-261 1 Apr. 1985 refs
Avail: NTIS HC A20/MF A01 CSCL 14B

The optimum sensor location problem, OSLP, may be thought of in terms of the set of systems, S, the class of input time functions, I, and the identification algorithm (estimator) used, E. Thus, for a given time history of input, the technique of determining the OSL requires, in general, the solution of the optimization and the identification problems simultaneously. A technique which uncouples the two problems is introduced. This is done by means of the concept of an efficient estimator for which the covariance of the parameter estimates is inversely proportional to the Fisher Information Matrix.
Author

N85-31211*# Lockheed Missiles and Space Co., Palo Alto, Calif.

EXPERIMENTAL VERIFICATION OF IDENTIFICATION ALGORITHMS FOR CONTROL OF FLEXIBLE STRUCTURES

B. SRIDHER, J. N. AUBRUN, and K. R. LORELL *In its* Proc. of the Workshop on Identification and Coastal of Flexible Space Struct., Vol. 3 p 283-297 1 Apr. 1985 refs

Avail: NTIS HC A20/MF A01 CSCL 22B

An on going simple laboratory experiment, referred to as the Beam Control Experiment (BCE) is described which has the essential features of a large flexible structure. The experiment is used to develop and evaluate identification and control algorithms which lock promising in the active control of high performance large space structures. Some results on the maximum likelihood identification of the parameters of the beam actuator sensor assembly from experimental data is presented. Author

N85-31212*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

AN EIGENSYSTEM REALIZATION ALGORITHM (ERA) FOR MODAL PARAMETER IDENTIFICATION AND MODEL REDUCTION

J. N. JUANG and R. S. PAPPA *In* JPL Proc. of the Workshop on Identification and Control of Flexible Space Struct., Vol. 3 p 299-318 1 Apr. 1985 refs

Avail: NTIS HC A20/MF A01 CSCL 22B

A method, called the Eigensystem Realization Algorithm (ERA), is developed for modal parameter identification and model reduction of dynamic systems from test data. A new approach is introduced in conjunction with the singular value decomposition technique to derive the basic formulation of minimum order realization which is an extended version of the Ho-Kalman algorithm. The basic formulation is then transformed into modal space for modal parameter identification. Two accuracy indicators are developed to quantitatively identify the system modes and noise modes. For illustration of the algorithm, examples are shown using simulation data and experimental data for a rectangular grid structure.

Author

N85-31213*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.

A RESIDUALS APPROACH TO FILTERING, SMOOTHING AND IDENTIFICATION FOR STATIC DISTRIBUTED SYSTEMS

G. RODRIGUEZ *In its* Proc. of the Workshop on Identification and Control of Flexible Space Struct., Vol. 3 p 319-376 1 Apr. 1985 refs

Avail: NTIS HC A20/MF A01 CSCL 22B

An approach for state estimation and identification of spatially distributed parameters embedded in static distributed (elliptic) system models is advanced. The method of maximum likelihood is used to find parameter values that maximize a likelihood functional for the system model, or equivalently, that minimize the negative logarithm of this functional. To find the minimum, a Newton-Raphson search is conducted that from an initial estimate generates a convergent sequence of parameter estimates. For simplicity, a Gauss-Markov approach is used to approximate the Hessian in terms of products of first derivatives. The gradient and approximate Hessian are computed by first arranging the negative log likelihood functional into a form based on the square root factorization of the predicted covariance of the measurement process. The resulting data processing approach, referred to here by the new term of predicted data covariance square root filtering, makes the gradient and approximate Hessian calculations very simple. A closely related set of state estimates is also produced by the maximum likelihood method: smoothed estimates that are optimal in a conditional mean sense and filtered estimates that emerge from the predicted data covariance square root filter.

Author

N85-31214*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.

NUMERICAL EXPERIMENTATION WITH MAXIMUM LIKELIHOOD IDENTIFICATION IN STATIC DISTRIBUTED SYSTEMS

R. E. SCHEID, JR. and G. RODRIGUEZ *In its* Proc. of the Workshop on Identification and Control of Flexible Space Struct., Vol. 3 p 377-402 1 Apr. 1985 refs

Avail: NTIS HC A20/MF A02 CSCL 22B

Many important issues in the control of large space structures are intimately related to the fundamental problem of parameter identification. One might also ask how well this identification process can be carried out in the presence of noisy data since no sensor system is perfect. With these considerations in mind the algorithms herein are designed to treat both the case of uncertainties in the modeling and uncertainties in the data. The analytical aspects of maximum likelihood identification are considered in some detail in another paper. The questions relevant to the implementation of these schemes are dealt with, particularly as they apply to models of large space structures. The emphasis is on the influence of the infinite dimensional character of the problem on finite dimensional implementations of the algorithms. Those areas of current and future analysis are highlighted which indicate the interplay between error analysis and possible truncations of the state and parameter spaces. Author

N85-32140# Honeywell Systems and Research Center, Minneapolis, Minn.

ROBUST CONTROL OF MULTIVARIABLE AND LARGE SPACE SYSTEMS Final Report, 7 Jan. 1982 - 30 Jun. 1984

J. D. DOYLE and T. B. CUNNINGHAM Mar. 1985 163 p

(Contract F49620-82-C-0090)

(AD-A155117; AFOSR-85-0473TR) Avail: NTIS HC A08/MF A01 CSCL 12A

This report, in the form of a set of notes, details Honeywell's research results of the past year in Robust Multivariable Control Theory. These notes are made up of four major parts. Part 0 gives a review of the required notation and mathematical background. Part 1 reviews recent results on the problem of analyzing the performance and robustness properties of systems. Part 2 presents the results on synthesis which are the highlight of this report, and Part 3 outlines how the methods of the previous parts apply to control of large space structures. Author (GRA)

N85-32829*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

ON A VARIATIONAL APPROACH TO SOME PARAMETER ESTIMATION PROBLEMS

H. T. BANKS (Brown Univ.) Jun. 1985 40 p refs Presented at the Intern. Conf. on Control Theory for Distributed Parameter Systems and Appl., Vorau, Austria, 9-14 Jul. 1984

(Contract NAS1-17070; NSF DMS-82-05355; AF-AFOSR-0398-84; DAAG29-83-K-0029)

(NASA-CR-177935; ICASE-85-32; NAS 1.26:177935; AD-A161114) Avail: NTIS HC A03/MF A01 CSCL 12A

Examples (1-D seismic, large flexible structures, bioturbation, nonlinear population dispersal) in which a variation setting can provide a convenient framework for convergence and stability arguments in parameter estimation problems are considered. Some of these examples are 1-D seismic, large flexible structures, bioturbation, and nonlinear population dispersal. Arguments for convergence and stability via a variational approach of least squares formulations of parameter estimation problems for partial differential equations is one aspect of the problem considered.

Author

N85-33179*# Hydraulic Research Textron, Irvine, Calif. Systems Engineering Div.
RESEARCH AND DEVELOPMENT ACTIVITIES IN UNIFIED CONTROL-STRUCTURE MODELING AND DESIGN
A. P. NAYAK 23 Jul. 1985 37 p Prepared in cooperation with JPL, Pasadena, Calif.
(Contract NAS7-918)
(NASA-CR-176129; JPL-9950-1167; NAS 1.26:176129; REPT-956541-EXT-2) Avail: NTIS HC A03/MF A01 CSCL 22B

Results of work to develop a unified control/structures modeling and design capability for large space structures modeling are presented. Recent analytical results are presented to demonstrate the significant interdependence between structural and control properties. A new design methodology is suggested in which the structure, material properties, dynamic model and control design are all optimized simultaneously. Parallel research done by other researchers is reviewed. The development of a methodology for global design optimization is recommended as a long-term goal. It is suggested that this methodology should be incorporated into computer aided engineering programs, which eventually will be supplemented by an expert system to aid design optimization.
B.W.

N85-33180*# Hydraulic Research Textron, Irvine, Calif. Systems Engineering Div.
RESEARCH AND DEVELOPMENT ACTIVITIES IN UNIFIED CONTROL-STRUCTURE MODELING AND DESIGN
A. P. NAYAK 3 May 1985 29 p refs Prepared in cooperation with JPL, Pasadena, Calif.
(Contract NAS7-918)
(NASA-CR-176111; JPL-9950-1144; NAS 1.26:176111; REPT-956541-EXT-2) Avail: NTIS HC A03/MF A01 CSCL 22B

Results of work sponsored by JPL and other organizations to develop a unified control/structures modeling and design capability for large space structures is presented. Recent analytical results are presented to demonstrate the significant interdependence between structural and control properties. A new design methodology is suggested in which the structure, material properties, dynamic model and control design are all optimized simultaneously. The development of a methodology for global design optimization is recommended as a long term goal. It is suggested that this methodology should be incorporated into computer aided engineering programs, which eventually will be supplemented by an expert system to aid design optimization. Recommendations are also presented for near term research activities at JPL. The key recommendation is to continue the development of integrated dynamic modeling/control design techniques, with special attention given to the development of structural models specially tailored to support design. Author

N85-33539*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
STRUCTURAL DYNAMICS MODEL AND RESPONSE OF THE DEPLOYABLE REFERENCE CONFIGURATION SPACE STATION
J. M. HOUSNER May 1985 93 p
(NASA-TM-86386; NAS 1.15:86386) Avail: NTIS HC A05/MF A01 CSCL 20K

The analytical models and results of a structural dynamics investigation of the reference initial operation and evolutionary configurations of the nine foot bay space station are presented. This investigation was carried out between April and August 1984 as part of a team effort to define a reference configuration for the first U.S. manned space station. The results presented herein serve as a guide, a point of departure and a standard for future NASA and contractor studies leading to the design of the Space Station. The reference initial operation configuration of the nine foot bay station was found to be very flexible, with its lowest mode between 0.096 and 0.138 Hertz depending on station attachments. However, for the transient load cases which were then available, internal member loads had positive margins of safety and preliminary results indicate that laboratory experiments which require quiescent conditions can be satisfied down to the order of 0.0001 g's. Author

N85-34148*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
SPACE STATION ROTATIONAL EQUATIONS OF MOTION
M. H. RHEINFURTH and S. N. CARROLL Aug. 1985 21 p
(NASA-TP-2511; NAS 1.60:2511) Avail: NTIS HC A02/MF A01 CSCL 22B

Dynamic equations of motion are developed which describe the rotational motion for a large space structure having rotating appendages. The presence of the appendages produce torque coupling terms which are dependent on the inertia properties of the appendages and the rotational rates for both the space structure and the appendages. These equations were formulated to incorporate into the Space Station Attitude Control and Stabilization Test Bed to accurately describe the influence rotating solar arrays and thermal radiators have on the dynamic behavior of the Space Station. Author

N85-35214*# Virginia Polytechnic Inst. and State Univ., Blacksburg. Dept. of Engineering Science and Mechanics.
IDENTIFICATION AND CONTROL OF STRUCTURES IN SPACE Progress Report, 1 Jan. - 30 Jun. 1985
L. MEIROVITCH 30 Jun. 1985 23 p refs
(Contract NAG1-225)
(NASA-CR-176175; NAS 1.26:176175) Avail: NTIS HC A02/MF A01 CSCL 22B

Work during the period January 1 to June 30, 1985 has concentrated on the completion of the derivation of the equations of motion for the Spacecraft Control Laboratory Experiment (SCOLE) as well on the development of a control scheme for the maneuvering of the spacecraft. The report consists of a paper presented at the Fifth Symposium on Dynamics and Control of Large Structures, June 12 to 14, 1985 at Blacksburg, VA.
Author

N85-35215*# Smithsonian Astrophysical Observatory, Cambridge, Mass.
THE INVESTIGATION OF TETHERED SATELLITE SYSTEM DYNAMICS Quarterly Report, 15 May - 14 Aug. 1985
E. LORENZINI Sep. 1985 71 p
(Contract NAS8-36160)
(NASA-CR-176180; NAS 1.26:176180; QR-4) Avail: NTIS HC A04/MF A01 CSCL 22B

Progress in tethered satellite system dynamics research is reported. A retrieval rate control law with no angular feedback to investigate the system's dynamic response was studied. The initial conditions for the computer code which simulates the satellite's rotational dynamics were extended to a generic orbit. The model of the satellite thrusters was modified to simulate a pulsed thrust, by making the SKYHOOK integrator suitable for dealing with delta functions without loosing computational efficiency. Tether breaks were simulated with the high resolution computer code SLACK3. Shuttle's maneuvers were tested. The electric potential around a severed conductive tether with insulator, in the case of a tether breakage at 20 km from the Shuttle, was computed. The electrodynamic hazards due to the breakage of the TSS electrodynamic tether in a plasma are evaluated. E.A.K.

N85-35641*# Avco Systems Div., Wilmington, Mass.
ENHANCEMENT OF THE FLEXIBLE SPACECRAFT DYNAMICS PROGRAM FOR OPEN SPACECRAFT Final Report
15 Mar. 1985 36 p refs
(Contract NAS5-28128)
(NASA-CR-175309; NAS 1.26:175309) Avail: NTIS HC A03/MF A01 CSCL 09B

The modifications and additions made to the Flexible Spacecraft Dynamics (FSD) Program are described. The principal addition to the program was the capability to simulate a single axis gimble platform nadir pointing despin control system. The formulation for the single axis gimble equations of motion is a modification of the

formulation. The details of the modifications made to the FSD Program are presented. Modifications to existing subroutines are briefly described and a detailed description of new subroutines is given. In addition, e program variables in new labelled COMMON blocks are described in detail. A description of new input symbols for the FSD Program is given. G.L.C.

07

POWER

Includes descriptions of analyses, systems, and trade studies of electric power generation, storage, conditioning and distribution.

A85-31098#
SPACE PHOTOVOLTAICS - PRESENT AND FUTURE
K. BOGUS (ESA, Spacecraft Technology Dept., Noordwijk, Netherlands) ESA Bulletin (ISSN 0376-4265), no. 41, Feb. 1985, p. 70-77.

Space photovoltaic technology in Europe is currently dominated by silicon cells mounted on deployable rigid or flexible panels. Europe leads in the application of large flexible blanket arrays for high-power missions (e.g. Space Telescope, Olympus) and is further developing the technology for retractable arrays. In the future, the increasing demand for high-power, minimum-area solar arrays will stimulate new technology development paths both at cell level (gallium arsenide and advanced silicon cells) and array level (planar blanket and advanced sunlight concentrator arrays). Author

A85-32227
ESTABLISHING AN ENERGY-RICH ENVIRONMENT FOR A SPACE STATION
A. A. SORENSEN (TRW, Inc., TRW Space and Technology Group, Redondo Beach, CA) IN: NTC '83; Proceedings of the National Telesystems Conference, San Francisco, CA, November 14-16, 1983 . New York, Institute of Electrical and Electronics Engineers, Inc., 1983, p. 378-383.

This paper discusses the probable technology for space station (or large spacecraft) electrical energy generation, storage and distribution. Specific size, mass, and cost parameters are given, assuming various technological maturities and advancements. Covered are planar and concentrator solar arrays, solar-dynamic, nuclear power sources, battery systems (various types), and reversible fuel cells. Tradeoffs for the selection of the power distribution approach are provided. Sizing and cost factors for the more reasonable combinations of source/storage/distribution are given so the cost of the space energy can be estimated. Although an 'energy rich' space environment is possible, the practical cost will dictate stringent energy conservation measures by all users. Author

A85-34537
CONCEPT OF THE LUNAR POWER SYSTEM
D. R. CRISWELL (California, University, La Jolla, CA) and R. D. WALDRON Space Solar Power Review (ISSN 0191-9067), vol. 5, no. 1, 1985, p. 53-75. refs

It is asserted that the development of efficient solar power systems is dependent on their placement in GEO (SPS) or on the moon (LPS). Conventional large scale power sources (fission, coal, hydrocarbons) will eventually be depleted and pose unacceptably high environmental risks. Fusion power plants will need an infrastructure that cannot yet be envisioned. Terrestrial solar, biomass and wind energy plants require large land areas and massive quantities of materials to achieve significant outputs. Orbiting SPS stations offer greater energy output/mass ratios than available on earth. The receiving rectenna would be of nearly the same mass of a large coal-burning power plant. Lunar materials could be used to build the SPS, or power plants on the moon. Lunar and terrestrial rotations would require relays in space to maintain a continuous power stream. The lunar soil, a good dielectric, could be made into a glass or ceramic to support solar cells in arrays covering 10,000 sq km. Finally, actual system features, as well as the necessity of planning for long payoff times in financing, are discussed. M.S.K.

A85-34540
ON THE PERFORMANCE AND LIFETIME OF SOLAR MIRROR FOILS IN SPACE
D. FINK, J. P. BIERSACK (Hahn-Meitner-Institut fuer Kernforschung, Berlin GmbH, Berlin, West Germany), and M. STAEDELE (Berlin, Freie Universitaet, Berlin, West Germany) Space Solar Power Review (ISSN 0191-9067), vol. 5, no. 1, 1985, p. 91-100. refs

The results of a Monte Carlo computer analysis of the long term effects of space radiation on the surfaces of giant orbiting mirrors are presented. The mirrors, thin surfaced and made of substances like, e.g., Mylar and Hostephan, which are polymers, would reflect solar radiation to earth and be of a size equivalent to that of the area they would illumine. Possible applications are the warming of cities, melting of icebergs in shipping lanes and the illumination of solar power plants. Attention was focused on the changes produced in the reflective surface by solar wind particle bombardment. It was found that an Al covering at least 0.1 mm thick would be needed for protection. Nevertheless, the surface would be destroyed by blistering and foil carbonization within 10 yr and would then require replacement. M.S.K.

A85-35602*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
PHOTOVOLTAICS - THE ENDLESS SPRING
H. W. BRANDHORST, JR. (NASA, Lewis Research Center, Cleveland, OH) IN: Photovoltaic Specialists Conference, 17th, Kissimmee, FL, May 1-4, 1984, Conference Record . New York, Institute of Electrical and Electronics Engineers, 1984, p. 1-6. Previously announced in STAR as N84-31782.

An overview of the developments in the photovoltaic field over the past decade or two is presened. Accomplishments in the terrestrial field are reviewed along with projections and challenges toward meeting cost goals. The contrasts and commonality of space and terrestrial photovoltaics are presented. Finally, a strategic philosophy of photovoltaics research highlighting critical factors, appropriate directions, emerging opportunities, and challenges of the future is given. Author

A85-35603*# National Aeronautics and Space Administration, Washington, D.C.
SPACE STATION POWER SYSTEM
A. F. FORESTIERI and C. R. BARAONA (NASA, Interim Space Station Program Office, Washington, DC) IN: Photovoltaic Specialists Conference, 17th, Kissimmee, FL, May 1-4, 1984, Conference Record . New York, Institute of Electrical and Electronics Engineers, 1984, p. 7-11.

A Space Station Task Force was established by the NASA Administrator in May 1982 to provide focus and direction for Space Station planning activities. The Task Force also provides Congress and the Administration with sufficient information to allow them to make an informed decision on whether the United States should proceed with a Space Station as the next major national initiative in space. This paper will present the status of planning activities to date, with major emphasis on the power system. Technology options, power requirements, and schedule will be discussed. Author

A85-35605#
SOLAR POWER REQUIREMENTS FOR MILITARY SPACE VEHICLES
J. F. WISE (USAF, Aero Propulsion Laboratory, Wright-Patterson AFB, OH) IN: Photovoltaic Specialists Conference, 17th, Kissimmee, FL, May 1-4, 1984, Conference Record . New York, Institute of Electrical and Electronics Engineers, 1984, p. 17-22. refs

Military space power requirements in the next ten years are 5 to 30 kW steady state. Because of limitations in the capability to

deliver satellites to orbit, size and weight of the solar array continue to be important. The capability to operate throughout all orbital regimes from low orbit equatorial and polar to midaltitude and in elliptical as well as the geosynchronous orbits is needed. Each of these orbital regimes has its own set of constraints which must be addressed in high power solar array technology. High altitude systems are severely weight-limited and spacecraft charging must be considered. Low altitude orbits will encounter plasma environments which may cause severe leakage currents especially at higher operating voltages. Midaltitude orbits encounter severe radiation environments as well as possible spacecraft charging. As the voltages increase, corona effects may be manifest as a result of outgassing environments internal to the spacecraft.
Author

A85-35638
A NEW GENERIC RANGE OF ADVANCED RIGID SOLAR ARRAYS FOR SPACE APPLICATIONS
A. M. V. VIELEERS (Fokker, Schiphol, Netherlands) IN: Photovoltaic Specialists Conference, 17th, Kissimmee, FL, May 1-4, 1984, Conference Record . New York, Institute of Electrical and Electronics Engineers, 1984, p. 310-314.

A group of generic rigid-solar-array designs developed for 3-axis-stabilized satellites is characterized and illustrated with diagrams, drawings, photographs, and tables of specifications. The advanced rigid array (ARA) concept provides for a basic unit comprising two identical and interchangeable wings of 3-7 panels (of up to 2.5 x 3.5 m each) and a mounting yoke and is optimized to deliver 2-4 kW power in GEO for up to 10 yrs. Topics examined include the specific ARA design features, the history of the ARA development program, the software approach, and the generic price agreement plan for marketing ARA. T.K.

A85-36123* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
EQUIVALENT ELECTRON FLUENCE FOR SPACE QUALIFICATION OF SHALLOW JUNCTION HETEROFACE GAAS SOLAR CELLS
J. W. WILSON (NASA, Langley Research Center, Hampton, VA) and L. V. STOCK (Old Dominion University, Norfolk, VA) IEEE Transactions on Electron Devices (ISSN 0018-9383), vol. ED-31, May 1984, p. 622-625. refs

It is desirable to perform qualification tests prior to deployment of solar cells in space power applications. Such test procedures are complicated by the complex mixture of differing radiation components in space which are difficult to simulate in ground test facilities. Although it has been shown that an equivalent electron fluence ratio cannot be uniquely defined for monoenergetic proton exposure of GaAs shallow junction cells, an equivalent electron fluence test can be defined for common spectral components of protons found in space. Equivalent electron fluence levels for the geosynchronous environment are presented. Author

A85-37164
A MINIATURIZED CASSEGRAINIAN CONCENTRATOR SOLAR ARRAY FOR HIGH POWER SPACE APPLICATIONS
R. E. PATTERSON and R. M. KURLAND (TRW, Inc., Space and Technology Group, Redondo Beach, CA) IN: New opportunities in space; Proceedings of the Twenty-first Space Congress, Cocoa Beach, FL, April 24-26, 1984 . Cape Canaveral, FL, Canaveral Council of Technical Societies, 1984, p. 5-1 to 5-8.

A miniaturized Cassegrainian concentrator (MCC) solar array system concept is under preliminary development for the Space Station or for other large spacecraft/space platform mission applications that may require power at the 100 kW level or higher. The concept has many of the physical attributes of planar rigid-panel solar arrays and does not require unusual deployment or thermal management methods or auxiliaries. Furthermore, it promises both lower initial cost and lower life cycle cost than state-of-the-art lightweight planar flexible blanket solar arrays. The paper briefly describes the MCC concept and presents the results of a life cycle cost comparison analysis that shows that solar array area (rather than weight) is the key cost parameter at the lowest candidate Space Station basing altitudes. With smaller area than its planar array counterpart, the MCC array offers a 20 to 30 percent reduction in life cycle cost. Author

A85-37172* Lockheed Missiles and Space Co., Sunnyvale, Calif.
STS 41-D SOLAR ARRAY FLIGHT EXPERIMENT
G. F. TURNER (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) and H. C. HILL (NASA, Marshall Space Flight Center, Huntsville, AL) IN: New opportunities in space; Proceedings of the Twenty-first Space Congress, Cocoa Beach, FL, April 24-26, 1984 . Cape Canaveral, FL, Canaveral Council of Technical Societies, 1984, p. 8-1 to 8-10.

The Solar Array Flight Experiment (SAFE) developed under the direction of the Marshall Space Flight Center, scheduled for launch on STS 41-D, will demonstrate a lightweight solar array technology which offers a factor of 3 improvement in weight and a factor of 10 improvement in specific volume over solar array systems currently in use in the space program. The experiment, which will include multiple deployment and retraction demonstration, verification of electrical and thermal performance, and verification of structural dynamic math models is 15 feet by 105 feet in size and, if completely covered with solar cells, would produce approximately 12.5 kW of electrical power. The unit has now been developed, tested, and is at Kennedy Space Center (KSC) being prepared for launch. Author

A85-37687#
SURFACE TEMPERATURE MEASUREMENT AND ANALYSIS OF A SOLAR ARRAY OPERATING WITH INDUCED, POWER DISSIPATING FAILURES UNDER ORBITAL CONDITIONS
C. STOWELL (General Electric Co., Philadelphia, PA) and P. PAPULA (RCA, Astro-Electronics Div., Princeton, NJ) American Institute of Aeronautics and Astronautics, Thermophysics Conference, 20th, Williamsburg, VA, June 19-21, 1985. 8 p. refs (AIAA PAPER 85-1080)

The environmental testing and techniques used in evaluating a space-conditioned solar array operating under simulated failure modes is discussed. These failure modes cause a local heating phenomenon of a solar array known as a 'hot spot' and is a major design obstacle. The empirically derived surface temperature of the solar array is compared to the time dependent thermal analysis playing a crucial role in the solar array evaluation. Special attention is given to the calibration of the infrared scanner used to monitor the solar array surface and the interpretation of its data into meaningful temperatures of a surface with an emittance less than one. Author

A85-38913#
THE INTEGRATION OF TERRESTRIAL AND EXTRATERRESTRIAL SOLAR GENERATORS INTO EXISTING POWER GENERATION SYSTEMS
B. STOY and U. BEYER (Rheinisch-Westfaelisches Elektrizitaetswerk AG, Essen, West Germany) IN: Symposium on Industrial Activity in Space, Stresa, Italy, May 2-4, 1984, Proceedings . Paris, Eurospace, 1984, p. 322-335.

The effectiveness of a decentralized terrestrial solar-power generation system and a solar-power-satellite/microwave-transmission generation system is analyzed comparatively for the case of the Federal Republic of Germany (FRG). The models considered are a 5-GW-peak-capacity network comprising one million 50-sq-m roof arrays of Si solar cells and the 5-GW-capacity 52-sq-km-array 100-sq-km-receiver reference satellite system proposed by the DOE and NASA; both models are assumed to be integrated into the present FRG power network, and the load requirements and system outputs are compared in a series of graphs and diagrams. The terrestrial system is found to provide no savings in grid-capacity or plant-capacity requirements and minimal fuel savings (at least in the FRG climate) corresponding to at most 5 Pfennig/kWh. The satellite system, assuming that a European grid can provide an emergency reserve, offers substantial fuel and plant-capacity savings corresponding to about 8.75 Pfennig/kWh. It is pointed out that the overall economy of these systems depends on the investment costs of installing them

(plus the investment cost of additional conventional plant capacity for the terrestrial model). T.K.

A85-39256
AUTONOMOUS SOLAR ARRAYS FOR THE FUTURE
T. M. TRUMBLE (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) IN: Space systems technology; Proceedings of the Aerospace Congress and Exposition, Long Beach, CA, October 15-18, 1984 . Warrendale, PA, Society of Automotive Engineers, Inc. (SAE SP-593), 1984, p. 35-38.
(SAE PAPER 841445)

Autonomous control technology for satellites is under development to provide long lifetimes of uninterrupted service at minimal costs. True autonomy, unattended satellite operation, can only occur after solar array power systems become autonomous. Distributed intelligence on the array, employment of expert systems, modulatization and on-array processing play key roles in achieving the goals of true solar array autonomy. Author

A85-39258
SOLAR DYNAMIC POWER FOR SPACE STATION
R. MCKENNA, R. NIGGEMANN, and P. THOLLOT (Sundstrand Corp., Sundstrand Advanced Technology Group, Rockford, IL) IN: Space systems technology; Proceedings of the Aerospace Congress and Exposition, Long Beach, CA, October 15-18, 1984 . Warrendale, PA, Society of Automotive Engineers, Inc. (SAE SP-593), 1984, p. 59-84. refs
(SAE PAPER 841524)

Power generation for the initial operational capability (IOC) of the NASA Space Station is expected to be in the range of 75-125 Kwe. Power growth from the 1992 IOC level is projected to reach 250-300 Kwe by 1997. The Space Station is to have an exceedingly long lifetime, a high reliability consistent with manned habitation, and be easy to maintain. Total life cycle cost and readily attainable schedules are key drivers in the program. The power generation system must likewise be compatible with these basic requirements. The Solar Dynamic Rankine Cycle is an approach whose state of technology readiness makes it an ideal candidate for power generation. Addressed are basic requirements, technology readiness, comparison to photovoltaic, and other dynamic power systems, cost effectiveness and interfacing with power management/distribution (PMAD). Author

A85-39260
THE EFFECT OF BIPROPELLANT THRUSTER CONTAMINANT ON SOLAR ARRAY PERFORMANCE
P. RAMIREZ (Rockwell International Corp., Satellite Systems Div., Pittsburgh, PA) IN: Space systems technology; Proceedings of the Aerospace Congress and Exposition, Long Beach, CA, October 15-18, 1984 . Warrendale, PA, Society of Automotive Engineers, Inc. (SAE SP-593), 1984, p. 93-99. Research sponsored by the International Telecommunications Satellite Organization. refs
(SAE PAPER 841526)

A large number of spacecraft scheduled to be launched in the 1980's and 1990's will utilize bipropellant attitude control thrusters. Contaminants generated during the pulse mode operation of these thrusters may impinge on the solar arrays. Over a ten-year operational lifetime, the accumulated contaminant may degrade the power output of the solar arrays. An experimental program was conducted to determine the effect of bipropellant thruster contaminants on a solar array. A representative contaminant was produced in the laboratory and was applied to three mini-solar arrays covering approximately 32, 41, and 57 percent of the surface area. A fourth uncontaminated mini-solar array was included to provide a basis for comparison. Pre- and post-contamination testing was conducted using a pulsed xenon solar simulator. A maximum degradation in solar array electrical power output of three percent was measured for the sample with 57 percent of the surface area covered with the contaminant. Author

A85-39464
LEASECRAFT POWER SYSTEM
P. R. K. CHETTY (Fairchild Space Co., Germantown, MD) IEEE Transactions on Aerospace and Electronic Systems (ISSN 0018-9251), vol. AES-21, May 1985, p. 420-426.

A detailed description is presented of the power system of Leasecraft, a satellite platform for low earth orbit missions to facilitate commercial development of space. Typical spacecraft power systems are first briefly reviewed, and the results of tradeoff studies are reported which led to the selection of a decentralized regulation concept utilizing a nondissipative unregulated main bus approach to the Leasecraft power system. The need for modularity is discussed, and the modular power system is addressed, including the power regulator unit, power control unit, bus protection assembly, signal conditioning assembly, storage batteries, remote interface unit, and heaters. C.D.

A85-39801#
A SOLAR DYNAMIC POWER CONVERSION SYSTEM FOR SPACE STATION
R. E. NIGGEMANN, R. F. MCKENNA, D. W. CHAUDOIR, and P. A. THOLLOT (Sundstrand Corp., Sundstrand Advanced Technology Group, Rockford, IL) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 21st, Monterey, CA, July 8-10, 1985. 8 p.
(AIAA PAPER 85-1480)

Dynamic (i.e., nonphotovoltaic) electric power generating systems are becoming more attractive as power needs of various space applications increase. A solar dynamic power system can provide the high power requirements of the Space Station at higher efficiencies and potentially lower costs than a photovoltaic system. The significant benefit is more recognizable in the reduction of frontal area or energy collection area of a spacecraft. For vehicles in low earth orbit (LEO), this relates to less drag, reduced susceptibility to jet exhaust disturbance, and less viewing and operational interference. Discussed here is a solar dynamic power generating system based on the Organic Rankine Cycle (ORC), suitable for the power generating requirements of NASA's Space Station. Also described is a power management and distribution scheme that provides the user directly with high quality, ac power at a frequency that is user friendly. Author

A85-41861
CRYOGENIC POWER DISTRIBUTION ON A SPACE POWER STATION
N. HIGUCHI, I. ISHII, I. KUDO, and Y. KIMURA (Ministry of International Trade and Industry, Electrotechnical Laboratory, Sakura, Japan) (University of Tokyo and Ministry of Education, Science, and Culture, Space Energy Symposium, 3rd, Tokyo, Japan, Mar. 26, 1984) Space Solar Power Review (ISSN 0191-9067), vol. 5, no. 2, 1985, p. 143-147. refs

A power distribution system to be used on a 5 GW space power station (SPS) is described. The system uses a low voltage dc superconducting cable (SC) to transport electric power 4 kV 10 kA of electric power from the solar collectors to the converting system. The maximum current of the collection system is determined by minimizing the summation of Joule losses and the refrigerating load. The cable is made of aluminum stabilized NbTi, and the negative and positive conductors are laid coaxially to suppress the magnetic field outside the cable. It is shown that the SC system provides greater efficiency and lower lift-off weight to the station in comparison with conventional cable systems. A cross section of the SC is shown. I.H.

A85-41865
FUNDAMENTAL STUDY OF FUEL CELL SYSTEM FOR SPACE VEHICLE
K. KIKUCHI, T. OZEKI, Y. YOSHIDA (Mitsubishi Heavy Industries, Ltd., Nagoya Aircraft Works, Nagoya, Japan), Y. FUJITA, and H. KUDO (Japan Storage Battery Co., Ltd., Kyoto) (University of Tokyo and Ministry of Education, Science, and Culture, Space Energy Symposium, 3rd, Tokyo, Japan, Mar. 26, 1984) Space Solar Power Review (ISSN 0191-9067), vol. 5, no. 2, 1985, p. 179-188.

In the future, satellites will become increasingly larger, and will require larger electric power. The solar array-storage battery combination will satisfy these power requirements because of its long life, light weight and high reliability. On the other hand, the fuel cell system will be mainly used for the winged re-entry vehicle, the orbital transfer vehicle, etc. A fundamental study of the alkaline-matrix type fuel cell system was carried out by using the experimental cell consisting of the anode and the cathode, separated by the asbestos matrix impregnated with electrolyte solution and the electrolyte reservoir plate made of porous nickel adjacent to the anode. The investigation was focused to establish the optimum operating condition which especially related to water balance. The 5 cell stack with an active area of 100 sq cm operated successfully, and put out a power of 79 W at 20 A. Author

A85-42551
COMPARISON OF NUCLEAR AND SOLAR POWER PLANTS WITH TURBOELECTRIC GENERATORS FOR APPLICATION IN SPACE
J. BLUMENBERG and H. O. RUPPE (Muenchen, Technische Universitaet, Munich, West Germany) (International Astronautical Federation, International Astronautical Congress, 32nd, Rome, Italy, Sept. 7-22, 1981) Acta Astronautica (ISSN 0094-5765), vol. 12, May 1985, p. 293-307.

The criterion of maximum thermodynamic efficiency versus specific mass was used to compare nuclear and solar power with turboelectric generators for applications in space. The specific design configurations examined were: a reactor system with a net electric power of 100 kWe; a reactor system with net power of 1000 kWe; and a reactor system of 10,000 kWe net electric power. Spherical and parabolic solar power plant configurations were also studied. The efficiency of the systems was investigated in three different operating modes: the Brayton process; the Rankine process; and the Carnot process. It is found that the distance to the sun was the most important factor determining the efficiency of the solar power generators. The optimum specific mass of the parabolic system increased to 40 kg/kWe with the Carnot process; 75 kg/kWe with the Rankine process; and 92 kg/kWe with the Brayton process. The optimum specific mass of the nuclear systems was 8-13 kg/kWe in all three operating modes. The minimum operating temperatures of the power plant designs were compared in order to determine an upper limit for the temperature resistance of a beryllium turboelectric generator. The results of the comparison are given. I.H.

A85-42557
LARGE POWER SYSTEMS FOR SPACE PLATFORM APPLICATION
J. RATH (Telefunken AG, Wedel, West Germany) IN: From Spacelab to Space Station; Proceedings of the Fifth Symposium, Hamburg, West Germany, October 3-5, 1984 . San Diego, CA, Univelt, Inc., 1985, p. 121-134.
(AAS PAPER 84-310)

The design of advanced power-supply systems for LEO and GEO space platforms planned for the near future is discussed and illustrated with diagrams, graphs of projected performance, and drawings. The primary functions of power systems are reviewed; the requirements of the planned Space Station (75 kW in the initial configuration) and the 1500-sq-m solar array designed to meet them are examined; planar and low-concentrating arrays and advanced solar cells are considered; and power conditioning, distribution, and storage systems are briefly characterized. T.K.

A85-42698#
UNIFORM POWER DISTRIBUTION INTERFACES FOR FUTURE SPACECRAFT
J. J. CAPART and D. M. OSULLIVAN (ESA, Power and Control Systems Div., Noordwijk, Netherlands) ESA Bulletin (ISSN 0376-4265), no. 42, May 1985, p. 64-69.

Consideration is given to specification of an ideal power interface system for future spacecraft. The interfaces need to be safe, power-efficient, impose no undue costs on users, and defined early in any spacecraft development effort. ESA first established a 28 V standard for most scientific satellites, with the exception of Spacelab, which had to interface with the Orbiter fuel cells. The 28 V standard was raised to 50 V, accompanied by invention of a high frequency inverter to provide ac current to users. The inverter now allows a standard interface for ac and dc systems. The ac small load users receive 20 kHz current. Adoption of a common NASA/ESA interface will be necessary for electrical systems design work for the Space Station. M.S.K.

A85-45357* Jet Propulsion Lab., California Inst. of Tech., Pasadena.
RECENT DEVELOPMENTS IN HIGH PERFORMANCE PLANAR SOLAR ARRAY TECHNOLOGY
J. SCOTT-MONCK and P. STELLA (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) IN: IECEC '84: Advanced energy systems - Their role in our future; Proceedings of the Nineteenth Intersociety Energy Conversion Engineering Conference, San Francisco, CA, August 19-24, 1984. Volume 1 . La Grange Park, IL, American Nuclear Society, 1984, p. 78-84. NASA-supported research. refs

The NASA-OAST high performance solar array program is described. The rationale for this effort, its objectives and strategy, as well as progress made during the past 5 years, are discussed. It is shown that welded, ultrathin silicon solar cell array blankets are on the verge of technical readiness. It is argued that the most reasonable approach to achieving more significant performance improvements (to about 300 W/kg) involves the development of a higher efficiency (16-18 percent AM0) solar cell and a lightweight, efficient structure. Author

A85-45362* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
ADVANCED IN SOLID STATE SWITCHGEAR TECHNOLOGY FOR LARGE SPACE POWER SYSTEMS
G. R. SUNDBERG (NASA, Lewis Research Center, Cleveland, OH) IN: IECEC '84: Advanced energy systems - Their role in our future; Proceedings of the Nineteenth Intersociety Energy Conversion Engineering Conference, San Francisco, CA, August 19-24, 1984. Volume 1 . La Grange Park, IL, American Nuclear Society, 1984, p. 123-132. Previously announced in STAR as N84-22891. refs

High voltage solid state remote power controllers (RPC's) and the required semiconductor power switches to provide baseline technology for large, high power distribution systems in the Space Station, all electric airplane and other advanced aerospace applications were developed. The RPC's were developed for dc voltages from 28 to 1200 V and ac voltages of 115, 230, and 440 V at frequencies of 400 Hz to 20 kHz. The benefits and operation of solid state RPC's and highlights of several developments to bring the RPC to technology readiness for future aerospace needs are examined. The 28 V dc Space Shuttle units, three RPC types at 120 V dc, two at 270/300 V dc, two at 230 V ac and several high power RPC models at voltages up to 1200 V dc with current ratings up to 100 A are reviewed. New technology programs to develop a new family of (DI)2 semiconductor switches and 20 kHz, 440 V ac RPC's are described. E.A.K.

A85-45363
HIGH-FREQUENCY, HIGH-VOLTAGE AC POWER FOR SPACE VEHICLES
J. W. MILDICE, L. J. WAPPES, and P. M. LINDBERG (General Dynamics Corp., Convair Div., San Diego, CA) IN: IECEC '84: Advanced energy systems - Their role in our future; Proceedings of the Nineteenth Intersociety Energy Conversion Engineering Conference, San Francisco, CA, August 19-24, 1984. Volume 1 . La Grange Park, IL, American Nuclear Society, 1984, p. 133-138.

Attention is given to the development of design criteria for low mass, cost-effective 'utility-type' ac aerospace electrical power applications, examining a proprietary systems-oriented approach and exploring the features and results of a proof-of-concept demonstration program. Quantitative performance results are presented for 1.0, 2.0, 5.0, and 25.0-kW single-phase and three-phase systems; these indicate that suitable design practices can exploit ac technologies' inherent advantages in spacecraft applications without compromise of cost, mass, or efficiency. O.C.

A85-45370* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
HIGH VOLTAGE-HIGH POWER COMPONENTS FOR LARGE SPACE POWER DISTRIBUTION SYSTEMS
D. D. RENZ (NASA, Lewis Research Center, Cleveland, OH) IN: IECEC '84: Advanced energy systems - Their role in our future; Proceedings of the Nineteenth Intersociety Energy Conversion Engineering Conference, San Francisco, CA, August 19-24, 1984. Volume 1 . La Grange Park, IL, American Nuclear Society, 1984, p. 176-184. Previously announced in STAR as N84-22615. refs

Space power components including a family of bipolar power switching transistors, fast switching power diodes, heat pipe cooled high frequency transformers and inductors, high frequency conduction cooled transformers, high power-high frequency capacitors, remote power controllers and rotary power transfer devices were developed. Many of these components such as the power switching transistors, power diodes and the high frequency capacitor are commercially available. All the other components were developed to the prototype level. The dc/dc series resonant converters were built to the 25 kW level. S.L.

A85-45378
MULTI-KILOWATT SOLAR POWER SYSTEM CONCEPT
A. KIRPICH and A. CHUNG (General Electric Co., Space Div., Valley Forge, PA) IN: IECEC '84: Advanced energy systems - Their role in our future; Proceedings of the Nineteenth Intersociety Energy Conversion Engineering Conference, San Francisco, CA, August 19-24, 1984. Volume 1 . La Grange Park, IL, American Nuclear Society, 1984, p. 229-232.

Attention is given to the conceptual design of a 24-kW solar space power system in which digital switching techniques furnish a convenient low dissipation method for the management of excess solar array output. The large solar array surfaces associated with this multi-kW power system are noted to be capable of exacerbating electrostatic discharge phenomena. The solar array is fixed to the main body of the satellite, so that both must be oriented toward the sun; this feature simplifies thermal control requirements through the establishment of constant conditions. O.C.

A85-45381
THERMIONIC INTEGRATED CIRCUIT TECHNOLOGY FOR HIGH POWER SPACE APPLICATIONS
S. R. YADAVALLI (General Electric Co., Space Div., Valley Forge, PA) IN: IECEC '84: Advanced energy systems - Their role in our future; Proceedings of the Nineteenth Intersociety Energy Conversion Engineering Conference, San Francisco, CA, August 19-24, 1984. Volume 1 . La Grange Park, IL, American Nuclear Society, 1984, p. 247-251. refs

Thermionic triode integrated circuit technology operates at up to 2000 V and at least tens of amperes, at temperatures as high as 800 C, with high tolerance to nuclear and other irradiation; these properties are potentially useful in large spacecraft power units, such as the SP-100 nuclear reactor. An evaluation is presently made of such a system, and its projected features are compared with those of a conventional semiconductor dissipative shunt regulator. Thermionic technology is noted to offer significant reductions in volume and weight for the heat dissipation and radiation shield subsystems. O.C.

A85-45387* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
A 37.5-KW POINT DESIGN COMPARISON OF THE NICKEL-CADMIUM BATTERY, BIPOLAR NICKEL-HYDROGEN BATTERY, AND REGENERATIVE HYDROGEN-OXYGEN FUEL CELL ENERGY STORAGE SUBSYSTEMS FOR LOW EARTH ORBIT
M. A. MANZO and M. A. HOBERECHT (NASA, Lewis Research Center, Cleveland, OH) IN: IECEC '84: Advanced energy systems - Their role in our future; Proceedings of the Nineteenth Intersociety Energy Conversion Engineering Conference, San Francisco, CA, August 19-24, 1984. Volume 1 . La Grange Park, IL, American Nuclear Society, 1984, p. 287-294. Previously announced in STAR as N84-23022.

Nickel-cadmium batteries, bipolar nickel-hydrogen batteries, and regenerative fuel cell storage subsystems were evaluated for use as the storage subsystem in a 37.5 kW power system for Space Station. Design requirements were set in order to establish a common baseline for comparison purposes. The storage subsystems were compared on the basis of effective energy density, round trip electrical efficiency, total subsystem weight and volume, and life. Author

A85-45393* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
ELECTRICAL POWER SYSTEMS FOR SPACE STATION
W. E. SIMON (NASA, Johnson Space Center, Houston, TX) IN: IECEC '84: Advanced energy systems - Their role in our future; Proceedings of the Nineteenth Intersociety Energy Conversion Engineering Conference, San Francisco, CA, August 19-24, 1984. Volume 1 . La Grange Park, IL, American Nuclear Society, 1984, p. 324-329.

Major challenges in power system development are described. Evolutionary growth, operational lifetime, and other design requirements are discussed. A pictorial view of weight-optimized power system applications shows which systems are best for missions of various lengths and required power level. Following definition of the major elements of the electrical power system, an overview of element options and a brief technology assessment are presented. Selected trade-study results show end-to-end system efficiencies, required photovoltaic power capability as a function of energy storage system efficiency, and comparisons with other systems such as a solar dynamic power system. Author

A85-45410
POWER CONDITIONING AND PROCESSING FOR THE EUROPEAN DIRECT BROADCAST OLYMPUS 1 SATELLITE
J. E. HAINES and F. FORATTINI (ESA, European Space Research and Technology Centre, Noordwijk, Netherlands) IN: IECEC '84: Advanced energy systems - Their role in our future; Proceedings of the Nineteenth Intersociety Energy Conversion Engineering Conference, San Francisco, CA, August 19-24, 1984. Volume 1 . La Grange Park, IL, American Nuclear Society, 1984, p. 442-447.

After two years of development activity, the power conditioning and processing systems for the Olympus 1 Direct Broadcast Satellite (DBS) of ESA have been developed. The technical characteristics of the primary power systems are described, including the solar array and its orientation; the batteries and battery management systems; and payload power processing elements. A schematic diagram of the primary power control system on Olympus 1 is provided. I.H.

A85-45413
SPACE STATION ELECTRICAL POWER SYSTEM TECHNOLOGY
A. A. SORENSEN (TRW, Inc., TRW Space and Technology Group, Redondo Beach, CA) IN: IECEC '84: Advanced energy systems - Their role in our future; Proceedings of the Nineteenth Intersociety Energy Conversion Engineering Conference, San Francisco, CA, August 19-24, 1984. Volume 1 . La Grange Park, IL, American Nuclear Society, 1984, p. 458-463.

NASA is beginning the development of both a permanently manned Space Station and of unmanned space platforms. Although the exact requirements have not been defined, the initial Space Station will likely require a considerable amount of electrical power. There are many options available for the source, storage and distribution of power/energy. Some of these technologies are better developed and more likely to be applied to the initial systems. This paper describes the results of power system technology studies as applied to manned space stations, and includes tradeoffs for power distribution selection. Sizing and cost factors are provided for the more probable combinations of power sources, storage and distribution approaches. Author

A85-45425* National Aeronautics and Space Administration, Washington, D.C.
NASA'S SPACE ENERGY TECHNOLOGY PROGRAM
J. P. MULLIN, D. C. BYERS, J. H. AMBRUS, and J. C. LORIA (NASA, Washington, DC) IN: IECEC '84: Advanced energy systems - Their role in our future; Proceedings of the Nineteenth Intersociety Energy Conversion Engineering Conference, San Francisco, CA, August 19-24, 1984. Volume 1 . La Grange Park, IL, American Nuclear Society, 1984, p. 542-549.

NASA's Space Energy Systems program is concerned with the development of technology for space missions requiring high performance, such as geostationary orbit communication satellites and planetary spacecraft, and high capacity, such as the planned Space Station and lunar bases; these two requirements often lead to great differences in system design. The program accordingly addresses a wide range of candidate technologies, which encompasses photovoltaics, chemical energy conversion and storage, thermoelectric conversion, power management and distribution, and thermal management. O.C.

A85-45437
BIPOLAR NICKEL-HYDROGEN BATTERY SYSTEM DESIGN
G. VAN OMMERING and C. W. KOEHLER (Ford Aerospace and Communications Corp., Palo Alto, CA) IN: IECEC '84: Advanced energy systems - Their role in our future; Proceedings of the Nineteenth Intersociety Energy Conversion Engineering Conference, San Francisco, CA, August 19-24, 1984. Volume 1 . La Grange Park, IL, American Nuclear Society, 1984, p. 625-630.

The bipolar nickel-hydrogen battery is a strong candidate for high-power space energy storage applications such as the Space Station and is now the subject of a NASA-sponsored development program. The baseline battery design established by Ford Aerospace for this program is configured to meet the fundamental design requirements for bipolar metal-gas batteries, in particular cell-to-cell thermal uniformity, materials management and cooling system reliability. Key elements of the battery are discussed, including the long, narrow rectangular cell design which permits a simple cooling configuration, elimination of cell-to-cell temperature gradients, sizing flexibility and a specific energy of nearly 39 Wh/kg. Author

A85-45961*# Rockwell International Corp., Downey, Calif.
WHEEL CONFIGURATIONS FOR COMBINED ENERGY STORAGE AND ATTITUDE CONTROL SYSTEMS
R. E. OGLEVIE (Rockwell International Corp., Space Station Systems Div., Downey, CA) IN: Guidance, Navigation and Control Conference, Snowmass, CO, August 19-21, 1985, Technical Papers . New York, AIAA, 1985, p. 788-798. Research sponsored by the Rockwell International Corp. and Charles Stark Draper Laboratory, Inc. refs
(Contract NAS1-17633)
(AIAA PAPER 85-1989)

Integrated power and attitude control system (IPACS) studies performed over a decade ago established the feasibility of simultaneously storing electrical energy in wheels and utilizing the resulting momentum for spacecraft attitude control. It was shown that such a system possessed many advantages over other contemporary energy storage and attitude control systems in many applications. More recent technology advances in composite rotors, magnetic bearings, and power control electronics have triggered new optimism regarding the feasibility and merits of such a system. This paper presents the results of a recent study whose focus was to define an advanced IPACS and to evaluate its merits for the Space Station application. Emphasis is given to the selection of the wheel configuration to perform the combined functions. A component design concept is developed to establish the system performance capability. A system-level trade study, including life-cycle costing, is performed to define the merits of the system relative to two other candidate systems. It is concluded that an advanced IPACS concept is not only feasible but offers substantial savings in mass and life-cycle cost. Author

A85-46596
GRUMMAN EVALUATES SPACE STATION THERMAL CONTROL AND POWER SYSTEMS
S. W. KANDEBO Aviation Week and Space Technology (ISSN 0005-2175), vol. 123, Sept. 2, 1985, p. 56, 57, 59, 60.

Attention is given to the definition of requirements for the NASA Space Station's electrical power and thermal control systems, which must be highly dependable to minimize the need for external support and will embody a highly flexible modular design concept. Module maintenance will be performed by in-orbit replacement of failed modules, and energy storage system growth will be accomplished by the incorporation of additional modules. Both photovoltaic and solar heat-driven electrical generator concepts are under consideration as the basis of the power system. O.C.

A85-47042*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
ELECTRIC POWER - PHOTOVOLTAIC OR SOLAR DYNAMIC?
R. L. THOMAS (NASA, Lewis Research Center, Cleveland, OH), G. J. HALLINAN (Rockwell International Corp., Rocketdyne Div., Canoga Park, CA), and J. L. HIEATT (TRW, Inc., TRW Space and Technology Group, Redondo Beach, CA) Aerospace America (ISSN 0740-722X), vol. 23, Sept. 1985, p. 60-62.

The design of the power system for supplying the Space Station with insolation-generated electricity is the main Phase B task at NASA-Lewis Center. The advantages and limitations of two types of power systems, the photovoltaic arrays (PV) and the solar dynamic system (SD), are discussed from the points of view of cost, overall systems integration, and growth. Subsystems of each of these options are described, and a sketch of a projected SD system is shown. The PV technology is well developed and proven, but its low efficiency calls for solar arrays of large areas, which affect station dynamics, control, and drag compensation. The SD systems would be less costly to operate than VP, and are more efficient, needing less deployed area. The major drawback of the SD is its infancy. The conservative and forgiving designs for some of its components must still be created and tested, and the development risks assessed. I.S.

A85-49442
SOLAR ENERGY AND SPACE FLIGHTS [SOLNECHNAIA ENERGIIA I KOSMICHESKIE POLETY]
V. A. GRILIKHES, P. P. ORLOV, and L. B. POPOV Moscow, Izdatel'stvo Nauka, 1984, 216 p. In Russian. refs

Principles of design and operation are presented for various types of space solar energy systems. Particular consideration is given to solar concentrators, high-temperature solar heat sources, solar thermal power plants, solar photoelectric (solar-cell) systems, solar-powered space engines (e.g., solar sails and solar thermal and electric rocket engines), and space solar power stations. The available literature on the subject is analyzed and systematized. B.J.

A85-49950
WILL SOLAR DYNAMIC POWER BE USED FOR THE SPACE STATION?
D. J. HOLT Aerospace Engineering (ISSN 0736-2536), vol. 5, Sept. 1985, p. 48-55.

The study focuses on solar dynamic power as a power source for the Space Station, with basic requirements being the 75-150-kW initial operational capability and provisions for the power system expansion from 250 to 300 kW, as well as a 28-day emergency power requirement. A comparison is made among the organic Rankine, closed Brayton, and kinematic Stirling systems, which exhibit low drag areas, weight, and cost, from the viewpoints of efficiency and life characteristics. The thermodynamic cycle and configuration of the organic Rankine system, which is noted to be ahead of other systems in the development stage, are detailed. Finally, consideration is given to the choice of working fluid and viable receiver storage materials. L.T.

N85-22498*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
AN INVESTIGATION OF ARC DISCHARGING ON NEGATIVELY BIASED DIELECTRIC CONDUCTOR SAMPLES IN A PLASMA
W. L. MILLER *In its* Spacecraft Environ. Interactions Technol. p 367-377 Mar. 1985 refs
Avail: NTIS HC A99/MF E03 CSCL 20I

Proposals are now being developed for the construction of high-power photovoltaic systems for operation in low Earth orbit, where the plasma number density is about 1,000 to 1,000,000 per cubic cm. Existing data indicate that interactions between the plasma and high-voltage surfaces of an orbiting power system will occur. In ground tests, where the applied voltage is increased negatively from ground, the array current collection shows an approximately linear rise until it terminates in arcing at greater than several hundred volts negative. This arcing may reduce the power generation efficiency and could possibly affect the low-level logic circuits of the spacecraft. Therefore it is important that the arcing phenomenon be well understood. This study is a survey of the behavior of different dielectric-conductor samples, including a solar cell module, that were biased negatively in a low-density plasma environment with the intent of defining arc discharge conditions and characteristics. Procedures and results are discussed. Author

N85-22519*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
SPACE TEST PROGRAM OF HIGH-VOLTAGE SOLAR ARRAY-SPACE PLASMA INTERACTIONS
M. R. CARRUTH, JR. (NASA. Marshall Space Flight Center, Huntsville, Ala.) and C. K. PURVIS *In its* Spacecraft Environ. Interactions Technol., 1983 p 619-635 Mar. 1985 refs
Avail: NTIS HC A99/MF E03 CSCL 10A

Future spacecraft, notably the proposed Space Station, will require power systems much larger than have previously been flown. It is recognized that at higher voltages, and at the relatively high plasma density present at low Earth orbital altitudes, undesirable interactions between the high voltage solar array and the space plasma will occur. Space experiments on high voltage solar array space plasma interactions in low Earth orbit are an absolute requirement for confident design of a higher voltage solar array. Experiments are presently being identified to provide the necessary space data for calibration of ground testing, validation of analytical models, and development of design guidelines required for confident design of high voltage solar arrays in space. A proposed flight experiment program which is designed to obtain the required data is summarized. B.W.

N85-22565# European Space Agency, Paris (France).
PHOTOVOLTAIC GENERATORS IN SPACE
W. R. BURKE, comp. Nov. 1984 461 p refs Partly in FRENCH and ENGLISH Proc. of 4th European Symp., Cannes, France, 18-20 Sep. 1984 by CNES, ESA and SNIAS
(ESA-SP-210; ISSN-0379-6566) Avail: NTIS HC A20/MF A01

Silicon and GaAs solar cells for spacecraft power supplies; space environment effects on solar cells; solar generator design, checkout, and calibration; electrical interfaces; solar blankets; and deployment and retraction mechanisms were discussed.

N85-22574# Societe Nationale Industrielle Aerospatiale, Cannes (France).
GALLIUM ARSENIDE ARRAYS VERSUS SILICON ARRAYS FOR SPACE APPLICATION
L. PELENC *In* ESA Photovoltaic Generators in Space p 53-56 Nov. 1984 refs
Avail: NTIS HC A20/MF A01

From the assumed performances (cost, efficiency, mass) of silicon solar cells and the solar arrays in the 1990's, the minimal requirements for gallium arsenide solar cells to be competitive when mounted on nonconcentrated or spinned solar arrays were determined. Results show that compared with a 10% EOL efficiency 100 micron thick silicon cell, a GaAs cell is competitive, if it is 13% to 14% EOL efficient, 200 to 250 microns thick, and 2 to 2.5 times silicon cost at bare cell level. Author (ESA)

N85-22579# Centro Informazioni Studi Esperienze, Milan (Italy).
DEVELOPMENT OF VERY THIN LARGE AREA GAAS SOLAR CELLS FOR SPACE APPLICATION
L. BERTOTTI and C. FLORES *In* ESA Photovoltaic Generators in Space p 83-87 Nov. 1984 refs Sponsored in part by CNR
Avail: NTIS HC A20/MF A01

The fabrication and performances of thin and ultrathin GaAs solar cells obtained by chemical etching methods based on dissolution of the substrate, using NH4OH and H2O2, with recovery of the gallium from the etching solutions are described. The cells are bound to cover glass before substrate removal. In the etch-stop technique a GaAlAs layer, grown between the substrate and the P-N junction, stops the chemical etching as the substrate is removed. Prototype 10 micron thick cells were produced with conversion efficiency of 14% and a power-to-mass ratio 400 W/kg. A method based on accurate spray-etching of the substrate avoids the growth of the GaAlAs etch-stop layer. Cells 2 x 2 cm, 60 microns thick, with an efficiency of 16% were fabricated. Author (ESA)

N85-22580*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
GAAS AND 3-5 COMPOUND SOLAR CELLS STATUS AND PROSPECTS FOR USE IN SPACE
D. J. FLOOD and D. J. BRINKER *In* ESA Photovoltaic Generators in Space p 89-94 Nov. 1984 refs
Avail: NTIS HC A20/MF A01 CSCL 21H

The status and prospects of GaAs and 3-5 compound thin film and heterojunction solar cells for space missions are reviewed. Cell types considered include n+/p shallow homojunction thin film GaAs cells, 100x concentration ratio p/n and n/p GaAs small area concentrator cells; mechanically-stacked, two-junction tandem cells; and three-junction monolithic cascade cells. Author (ESA)

N85-22581# Centre National de la Recherche Scientifique, Toulouse (France). Lab. d'Automatique et d'Analyse des Systemes.
GAALAS-GAAS SOLAR CELL DEVELOPMENT: PROSPECTIVE FOR SPACE APPLICATIONS UNDER CONCENTRATION
F. THEREZ, A. CHIKOUCHE, R. ALCUBILLA, D. BIELLE-DASPET, M. ROUX (ONERA, Toulouse), and R. REULET (ONERA, Toulouse) *In* ESA Photovoltaic Generators in Space p 95-99 Nov. 1984 refs
(Contract CNRS-3870.01)
Avail: NTIS HC A20/MF A01

GaAlAs-GaAs solar cells were fabricated by liquid phase epitaxy in a process using supercooled melts. Epitaxial layers with smooth surfaces are produced. Layer uniformity improvements give reproducible results in the fabrication of GaAs devices. The cells utilize thin GaAlAs window layers. In order to better understand the electrical characteristics of the cells, the 2 kT direct current in GaAs diodes was analyzed, studying its dependence on surface area and perimeter value. The photovoltaic samples efficiency is 20.2% for low concentrated incident power density of 0.4 W/sq cm. Radiation damage on GaAs was studied. Author (ESA)

N85-22587# Office National d'Etudes et de Recherches Aerospatiales, Toulouse (France). Centre d'Etudes et Recherches Techniques.
INVESTIGATION OF THE DEGRADATION OF GAAS PHOTOVOLTAIC CELLS BY PROTON AND ELECTRON IRRADIATION [ETUDE DE LA DEGRADATION DES PHOTOPILES ASGA SOUS IRRADIATIONS PAR PROTONS ET ELECTRONS]
J. BERNARD, J. BOURRIEAU, R. REULET, M. ROUX, A. SUZUKI (Sharp Corp., Shinjo-cho, Japan), and K. SUGAWARA (Sharp Corp., Shinjo-cho, Japan) *In* ESA Photovoltaic Generators in Space p 137-142 Nov. 1984 refs In FRENCH
Avail: NTIS HC A20/MF A01

Variations in short circuit and open circuit current, and in maximum power of GaAlAs and GaAs photovoltaic cells as a function of electron and proton irradiation energy were studied. Proton energies were 0.25, 0.4, 0.7, 1.5, and 10 MeV. Electron energies were 1 and 2 MeV. A numerical model of proton degradation which includes space environment constraints was developed and applied to proton flux received by a geostationary satellite. Results confirm the advantages of GaAs solar cells for space missions. Author (ESA)

N85-22588# Ceskoslovenska Akademie Ved, Prague. Inst. of Physics.
IN-ORBIT LASER REGENERATION OF THE RADIATION DAMAGED SOLAR ARRAYS
V. POULEK *In* ESA Photovoltaic Generators in Space p 143-148 Nov. 1984 refs
Avail: NTIS HC A20/MF A01

Experiments with scanning laser beam annealing of complete satellite solar panels were studied as a means of regenerating the solar cells of geostationary communication satellites. A spaceborne system is proposed. Ground simulations indicate no laser damage of individual cells or the panel; 25% power increase; 0.1% mass increase; and 0.5% cost increase. No changes in satellite construction or launcher are needed. Author (ESA)

N85-22589# AEG-Telefunken, Wedel (West Germany).
GIOTTO SOLAR ARRAY: DESIGN, MANUFACTURE AND TEST
K. DETTLAFF, J. KOCH, and B. WODKE *In* ESA Photovoltaic Generators in Space p 151-155 Nov. 1984 refs
Avail: NTIS HC A20/MF A01

The manufacturing and testing of Giotto satellite solar array panels and samples are described. On nearing Halley's comet the satellite passes into a high particle density area and may be destroyed, so to ensure data transmission for as long as possible the solar arrays charge internal batteries and act as a shield. Panel design was derived from tests on small samples to decide bonding and manufacturing sequences; large-sample tests with solar cells and interconnections; an engineering panel integrated into the spacecraft model; and a qualification panel which is also a spare flight panel. Author (ESA)

N85-22590# Messerschmitt-Boelkow-Blohm G.m.b.H., Ottobrunn (West Germany).
THE DFS-KOPERNIKUS SOLAR GENERATOR ELECTRICAL DESIGN
L. PREUSS *In* ESA Photovoltaic Generators in Space p 157-162 Nov. 1984 refs
Avail: NTIS HC A20/MF A01

The electrical layout of the DFS satellite solar generator; the techniques applied for technical verification; and experience using an existing solar generator with modifications (INTELSAT 5) are described. The DFS is three-axis stabilized, in geosynchronous orbit. Power is supplied by two identical solar generator wings. The power required at end of life equinox (after 10.3 yr in worst case conditions) is 1150W. Each wing consists of three rigid panels and a yoke which serves as a connection link to the satellite bearing and power transfer assembly. The solar cell arrays on the panels are identical, except that the array on the center panel of each wing is turned around by 180 deg to fit with the unsymmetric hold down points and to balance the magnetic moment of the wing. Reutilization of the INTELSAT concept required a complete redesign of electrical cabling. Author (ESA)

N85-22592# Messerschmitt-Boelkow-Blohm G.m.b.H., Ottobrunn (West Germany).
ELECTRICAL DESIGN OF THE INTELSAT 6 SOLAR GENERATOR
G. LAROCHE *In* ESA Photovoltaic Generators in Space p 169-176 Nov. 1984 refs
Avail: NTIS HC A20/MF A01

The INTELSAT 6 10 kW installed power solar array is described. A dual cylindrical solar panel concept is utilized. During launch, the outer cylindrical panel is placed over the inner solar panel and main body of the satellite. Once in orbit, the outer panel telescopes downward to expose the upper panel. Together the 2 panels generate a minimum of 2.1 kW electric power during a 10 yr mission in geostationary orbit. The design verification tests are summarized. Author (ESA)

N85-22593# Royal Netherlands Aircraft Factories Fokker, Schiphol-Oost. Space Div.
COMPUTER AIDED ENGINEERING APPLIED TO THE DESIGN AND VERIFICATION OF THE GENERIC ADVANCED RIGID ARRAY (ARA)
C. K. WAFELBAKKER *In* ESA Photovoltaic Generators in Space p 177-185 Nov. 1984
Avail: NTIS HC A20/MF A01

Mechanical, thermal, electrical and geometrical programs for solar array design were created. Programs to calculate modes and frequency responses of panels and stowed wings with the panels modeled as beams; programs to deal with the lowest modes of the deployed wing; and programs to calculate solar cell operating temperature for open weave face skin panels were developed. The chain of analyses, from conceptual phase to solar array verification is automated. Author (ESA)

N85-22594# AEG-Telefunken, Wedel (West Germany).
DEVELOPMENT AND QUALIFICATION OF THE ELECTRICAL PART OF THE ADVANCED RIGID ARRAY (ARA)
D. POECK and B. GOERGENS *In* ESA Photovoltaic Generators in Space p 187-190 Nov. 1984
Avail: NTIS HC A20/MF A01

The impact of different solar cells on the power to mass ratio of the solar array was investigated. A 50 micron back surface field reflector (BSFR) cell with a 50 micron CMX coverglass has the highest possible power to mass ratio at end of life (EOL), 10 yr geostationary orbit. A 180 micron BSFR cell gives a higher EOL-power to mass ratio than all BSR cells, assuming array structure of 70 mg/sq cm or thicker ones. The hold down point sensitivity analysis shows that cell loss near hold down points

can be minimized by using different cell dimensions. Due to the multielement laser scribing technique, every required special cell dimension can easily be manufactured. Two Advanced Rigid Array design verification test samples were manufactured. Both samples successfully sustained 2000 deep thermal cycles between +80 and minus 180 C. Author (ESA)

N85-22595# Societe Nationale Industrielle Aerospatiale, Cannes (France).
SPOT SOLAR ARRAY
R. KRAWCZYK and L. DECRAMER (CNES, Toulouse) *In* ESA Photovoltaic Generators in Space p 191-199 Nov. 1984
Avail: NTIS HC A20/MF A01

The SPOT (French satellite) double deployment direction flexible foldout solar array is described. Its power can be adapted between 1 and 1.8 kW after 2 yr in low orbit. Mass = 154 kg. The spring loaded deployment system is illustrated. The pantographs, stowage box, and solar skins are shown. Possible performance improvements are indicated. Author (ESA)

N85-22596# Societe Nationale Industrielle Aerospatiale, Cannes (France).
RIGID SOLAR GENERATOR (GSR) SOLAR ARRAYS
G. A. MARTIN, R. LAGET, G. URBAIN, and J. L. BASTARD *In* ESA Photovoltaic Generators in Space p 203-209 Nov. 1984 refs
Avail: NTIS HC A20/MF A01

The Telecom, TV-SAT, and Arabsat Solar arrays are described. The Telecom minimal power requirement of 110 W during the spinned transfer phase (solar array stowed on the spacecraft walls) and 1054 W summer solstice on orbit (3 axis stabilized), led to a 3 panels per wing solar array; panel dimensions: 1295.4 x 2047 mm. The TV-SAT and Arabsat arrays differ from Telecom by their partial deployment in transfer orbit. The arrays contain 14,256 solar cells for primary power and 1560 cells for battery charging. Cells are 180 micron thick back surface reflectors. Author (ESA)

N85-22597# Societe Nationale Industrielle Aerospatiale, Cannes (France). Div. Systemes Balistique et Spatiaux.
RETRACTABLE RIGID SOLAR GENERATOR (GSR)
P. BOBO *In* ESA Photovoltaic Generators in Space p 211-215 Nov. 1984 refs
Avail: NTIS HC A20/MF A01

A retractable rigid 6 kW solar array is described. The deployment-retraction system uses a pantograph, with retraction ensured by an electric motor pulling a cable fixed to the outermost panel. Panel structure is similar to TV-SAT, but with wrapped rather than woven carbon fibers. Extension to 10 kW appears feasible. Author (ESA)

N85-22598# European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk (Netherlands). Olympus Program Office.
DERIVATION OF THE OLYMPUS SOLAR ARRAY REQUIREMENTS
R. STEELS and A. DICKINSON *In* ESA Photovoltaic Generators in Space p 217-220 Nov. 1984
Avail: NTIS HC A20/MF A01

Following a market survey, the potential for a large multipurpose platform to support satellite communications services was established. The process by which anticipated service requirements were translated into payload accommodation requirements and, through a series of system level tradeoffs, into requirements related to the solar array is described. Design requirements arising from transfer orbit stabilization options are outlined. Configurational tradeoffs, shuttle launch constraints, and system level requirements are reviewed. Author (ESA)

N85-22599# Spar Aerospace Ltd., Toronto (Ontario).
THE OLYMPUS SOLAR ARRAY DEVELOPMENT AND TEST PROGRAM
G. W. MARKS, C. ANDERS, S. DRAISEY, and M. ELEZKI *In* ESA Photovoltaic Generators in Space p 221-235 Nov. 1984
Avail: NTIS HC A20/MF A01

The test program for the Olympus satellite solar array was derived from a coordinated verification plan structured to verify all design variants of the array through the specified power generating range. Test and analysis programs are complementary such that where possible tests are carried out which verify worst cases for the generic design; otherwise, the test program provides inputs to analyses which extrapolate to the complete range. Electrical power output; release and deployment mechanisms; and stowed and deployment structural performance are tested. Author (ESA)

N85-22600# AEG-Telefunken, Wedel (West Germany).
DESIGN AND QUALIFICATION TESTING OF THE OLYMPUS SOLAR ARRAY BLANKET
L. GERLACH and G. KUECHLER *In* ESA Photovoltaic Generators in Space p 237-241 Nov. 1984 refs
Avail: NTIS HC A20/MF A01

The design of the Olympus solar array blanket, based on the shadow protection shunt diode concept and the necessary protection against charging of the blanket during the satellite's geosynchronous mission is described. The electrical rearside connection; the locating cup design; test results from the development program; data from flight production; and optimization with respect to thermo-optical data of the anticharging layer and the solar cell shunt concept are summarized. Author (ESA)

N85-22601# British Aerospace Dynamics Group, Stevenage (England). Space and Communications Div.
THE PERFORMANCE OF THE OLYMPUS POWER SUBSYSTEM WITH ITS SOLAR ARRAY
R. B. A. HARRIS *In* ESA Photovoltaic Generators in Space p 243-246 Nov. 1984 refs
Avail: NTIS HC A20/MF A01

Performance predictions and power subsystem results of the Olympus satellite with its solar array are summarized. The power subsystem embodies the method of sequential shunt regulation of solar array power developed for the ECS/MARECS satellites to produce a single regulated 50 V power bus. The solar array, which may be matched to a spacecraft power requirement by the addition of solar array panels, is used by the power subsystem to give a satellite capability expandable from 2.8 to 7.8 kW. Despite switching delays due to shunt switching, the system meets specifications. Author (ESA)

N85-22602# European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk (Netherlands).
SURVIVAL TESTING OF SILICON SOLAR MODULES
J. C. LARUE *In* ESA Photovoltaic Generators in Space p 249-256 Nov. 1984 refs
Avail: NTIS HC A20/MF A01

The survival testing and inspection of 100 solar modules are discussed. Accelerated thermal cycling, thermal vacuum electrical continuity, dissection, flexing, and visual, infrared and X-ray inspection are described. The most critical survival parameter is extended thermal cycling. The most critical module component is the solar cell series interconnector; the silver coated molybdenum interconnector survives 60,000 low Earth orbit or 1000 geostationary orbit eclipses (10 yr operational life). Further work is needed to reach this level of confidence with silver or aluminum interconnectors. Author (ESA)

N85-22606# Royal Aircraft Establishment, Farnborough (England).
ANALYSIS OF OPTIMUM FRONT COVER THICKNESS FOR LIGHTWEIGHT SOLAR ARRAYS
M. A. H. DAVIES, M. W. WALKDEN, and P. A. WHITE *In* ESA Photovoltaic Generators in Space p 279-288 Nov. 1984 refs Sponsored by Intelsat
Avail: NTIS HC A20/MF A01

Solar cell coverslide thickness required to give the highest power to weight ratio for a solar array 10 yr geosynchronous mission was analyzed. It is found that the optimum thickness is less than is commercially available, and is 18 microns excluding adhesive. An experiment to corroborate the analysis was conducted, using the thinnest coverslides available, 50 and 80 microns. Covered cells were irradiated at the front and rear by 3 electron and 5 proton energies, the omnidirectional fluences of which represented a 10 yr geosynchronous environment. Agreement between theory and experiment is good.
Author (ESA)

N85-22609# AEG-Telefunken, Wedel (West Germany).
CONCENTRATOR TECHNOLOGIES EVALUATION FOR LARGE SOLAR ARRAYS AND THEIR APPLICATION FOR SPACE STATIONS/PLATFORMS
W. WESTPHAL and J. RATH *In* ESA Photovoltaic Generators in Space p 305-311 Nov. 1984 refs
Avail: NTIS HC A20/MF A01

Solar concentrator technologies were compared for use in a manned space station. A SOLA type array is recommended for development. Comparisons show that low concentration (LC) and Cassegrain devices are extremely sensitive contaminative environments. Cassegrain systems have complex structures with low manufacturing tolerances (especially as micro-versions). The LC-tetrahedral frustrum pointing accuracy required is 7 deg (at 90% output). Cassegrain pointing accuracy required is 0.4 deg (at 90% output) which makes necessary extreme control systems (at required array size). Gallium arsenide cells do not show predicted or lab item properties and effectiveness as production line items.
Author (ESA)

N85-22610*# National Aeronautics and Space Administration, Washington, D.C.
SPACE STATION SOLAR ARRAY
A. F. FORESTIERI *In* ESA Photovoltaic Generators in Space p 313-319 Nov. 1984 refs
Avail: NTIS HC A20/MF A01 CSCL 21H

Space station solar array configurations and power system technologies were compared. Planar silicon arrays offer low technology risk but high weight and drag area. Concentrator arrays of silicon or gallium arsenide (preferred) promise lower cost and drag area but increase technology risk. Planar and power tower require fewer control moment gyros (CMG's). Delta is more rigid but requires more CMG's. Flexible body effects are not significant. All configurations can be assembled. Power tower is preferred for proximity operations. All configurations require 6 to 8 launches. Manned operations after two to three. All configurations can accommodate all candidate electrical power systems options.
Author (ESA)

N85-22611# Telespazio, S.p.A., Rome (Italy).
SOLAR ARRAY DYNAMICAL SIMULATION FOR ILLUMINATION AND TEMPERATURE VARIATION
M. RETICCIOLI and G. MOCCI *In* ESA Photovoltaic Generators in Space p 321-331 Nov. 1984 refs
Avail: NTIS HC A20/MF A01

A lumped parameter electrical model of spacecraft solar arrays was developed. It takes dynamically into account array temperature and illumination variations, to simulate electrical performances during spacecraft sunlight transient events (eclipse emergence, panel reorientation). Computer simulations of solar array output characteristics in different spacecraft environmental conditions are presented.
Author (ESA)

N85-22614# AEG-Telefunken, Wedel (West Germany).
ASPECTS OF LOW COST MODULE TECHNOLOGY
H. BEBERMEIER *In* ESA Photovoltaic Generators in Space p 349-352 Nov. 1984
Avail: NTIS HC A20/MF A01

Low cost and high performance technologies for a 30 kW low Earth orbit (LEO) solar array were analyzed to identify cost relations at module level. A test program was performed to identify lifetime and performance limitations for low cost and terrestrial components. Thick back surface field (BSF) cells are recommended for LEO applications, thin BSF or back surface reflector cells for geostationary applications. Ultrasonic welds of aluminum materials survived 10,000 LEO cycles with extrapolation to 50,000 feasible. For large, flexible arrays, a low cost technology (1 ohm/cm, 400 micron cell) and a high performance (bifacial cell module) are preferred.
Author (ESA)

N85-22617*# National Aeronautics and Space Administration, Washington, D.C.
NASA PHOTOVOLTAIC RESEARCH AND TECHNOLOGY DEVELOPMENT PROGRAM FOR SPACE APPLICATIONS
J. P. MULLIN, D. J. FLOOD (NASA. Lewis Research Center), and H. W. BRANDHORST, JR. (NASA. Lewis Research Center) *In* ESA Photovoltaic Generators in Space p 367-371 Nov. 1984
Avail: NTIS HC A20/MF A01 CSCL 21H

Photovoltaic cell and solar array NASA programs are reviewed, and the impact of missions such as the Columbus orbital space station on spaceborne energy technology is discussed. Estimates of power levels for the initial station range from 50 to 125 kW. A station requiring 125 kW requires an array output 300 kW, i.e., 2.5 times the total power generating capacity launched by NASA in the past 20 yr. Technologies considered include concentrator arrays, lithium counterdoped cells, GaAs cells, and three-junction monolithically grown cascade cells.
Author (ESA)

N85-22621# Royal Netherlands Aircraft Factories Fokker, Schiphol-Oost. Space Div.
GENERIC DESIGN AND VERIFICATION OF AN ADVANCED RIGID ARRAY (ARA)
D. MAWIRA *In* ESA Photovoltaic Generators in Space p 399-406 Nov. 1984 refs
Avail: NTIS HC A20/MF A01

A 2 to 4 kW rigid solar array suitable for a variety of space applications was designed. Panel size, number of panels, yoke length, and number and location of hold down points are variable. The panel structure is a full depth honeycomb aluminum core with carbon fiber faces. Design verification philosophy is outlined.
Author (ESA)

N85-22625# European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk (Netherlands).
GROWTH CAPABILITIES OF EUROPEAN RETRACTABLE SOLAR ARRAYS
R. L. CRABB *In* ESA Photovoltaic Generators in Space p 425-432 Nov. 1984
Avail: NTIS HC A20/MF A01

A parametric design evaluation was undertaken to examine ways of stretching existing solar array designs to meet intermediate power levels from 6 to 18 kW. The study was confined to interfaces pertinent to the STS and a retrievable carrier design reference mission. All the solar arrays studied could be stretched with varying degrees of ease to meet the 18 kW target. Mass estimates range from 298 to 600 kg, the main design driver being the in-orbit dynamic loads specified.
Author (ESA)

N85-23861*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.

SOLAR ARRAY EXPERIMENT (SAE) FLIGHT EXPERIENCE

H. C. HILL, L. E. YOUNG, and G. F. TURNER (Lockheed Missiles and Space Co., Sunnyvale, Calif.) *In* NASA. Langley Research Center Large Space Antenna systems Technol., 1984, Pt. 2 p 845-854 Apr. 1985

Avail: NTIS HC A21/MF A01 CSCL 10A

The space flight testing of a large, flat, flexible panel solar array is examined. The experiment objectives are: to demonstrate the functional operational of the wind deployment and packaging system; Electrical performance; Thermal performance; and dynamic performance. A complete description of the experiment and the flight results are given. E.R.

N85-25384*# United Technologies Corp., South Windsor, Conn. Power Systems Div.

LONG-LIFE HIGH PERFORMANCE FUEL CELL PROGRAM Interim Report, 28 May 1981 - 31 Oct. 1984

R. E. MARTIN Feb. 1985 187 p refs

(Contract NAS3-22234)

(NASA-CR-174874; NAS 1.26:174874; FCR-6853) Avail: NTIS HC A09/MF A01 CSCL 10B

A multihundred kilowatt Regenerative Fuel Cell for use in a space station is envisioned. Three 0.508 sq ft (471.9 cm) active area multicell stacks were assembled and endurance tested. The long term performance stability of the platinum on carbon catalyst configuration suitability of the lightweight graphite electrolyte reservoir plate, the stability of the free standing butyl bonded potassium titanate matrix structure, and the long life potential of a hybrid polysulfone cell edge frame construction were demonstrated. A 18,000 hour demonstration test of multicell stack to a continuous cyclical load profile was conducted. A total of 12,000 cycles was completed, confirming the ability of the alkaline fuel cell to operate to a load profile simulating Regenerative Fuel Cell operation. An orbiter production hydrogen recirculation pump employed in support of the cyclical load profile test completed 13,000 hours of maintenance free operation. Laboratory endurance tests demonstrated the suitability of the butyl bonded potassium matrix, perforated nickel foil electrode substrates, and carbon ribbed substrate anode for use in the alkaline fuel cell. Corrosion testing of materials at 250 F (121.1 C) in 42% wgt. potassium identified ceria, zirconia, strontium titanate, strontium zirconate and lithium cobaltate as candidate matrix materials. A.R.H.

N85-25741# Danish Research Center for Applied Electronics, Hoersholm.

ANALYSIS AND TESTING OF THE THERMAL PROPERTIES OF SPACE BATTERY CELLS, PHASE B, DRAFT Final Report

A. LAURSEN and P. H. JACOBSEN Paris ESA May 1984 61 p refs Sponsored in part by ESA

(Contract ESA-4981/82/HL-JS(SC))

(ESA-CR(P)-1971) Avail: NTIS HC A04/MF A01

Thermal studies on SAFT cells NiH2 HRN 42S2, AgH2 HRA 26S, and NiCd Vo24 are summarized. Measurement of heat flow in cells during cyclic operation; calculation of thermal capacity; and measurement of thermal capacity are described. Low orbit cycling and geostationary orbit cycling tests were performed.

Author (ESA)

N85-25844*# Hughes Space and Communications Group, El Segundo, Calif.

NASA WELDING ASSESSMENT PROGRAM Final Report

E. J. STOFEL Dec. 1984 44 p refs

(Contract NAS7-918)

(NASA-CR-175682; JPL-9950-1069; NAS 1.26:175682) Avail: NTIS HC A03/MF A01 CSCL 13H

A long duration test has been conducted for comparing various methods of attaching electrical interconnects to solar cells for near Earth orbit spacecraft. Representative solar array modules have been thermally cycled for 36,000 cycles between -80 and +80 C on this JPL and NASA Lewis Research Center sponsored work. This test simulates the environmental stress of more than 6 years on a near Earth spacecraft as it cycles in and out of the Earth's shadow. Evaluations of the integrity of these modules were made by visual and by electrical examinations before starting the cycling and then at periodic intervals during the cycling tests. Modules included examples of parallel gap and of ultrasonic welding, as well as soldering. The materials and fabrication processes are state of the art, suitable for forming large solar arrays of spacecraft quality. The modules survived his extensive cycling without detectable degradation in their ability to generate power under sunlight illumination. Author

N85-26912*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

TETHERED NUCLEAR POWER FOR THE SPACE STATION

D. J. BENTS 1985 27 p refs Proposed for presentation at the 20th Intersoc. Energy Conversion Eng. Conf. (IECEC), Miami Beach, Fla., 18-23 Aug. 1985; sponsored by SAE, ANS, ASME, IEEE, AIAA, ACS, and AIChE

(NASA-TM-87023; E-2572; NAS 1.15:87023) Avail: NTIS HC A03/MF A01 CSCL 18L

A nuclear space power system the SP-100 is being developed for future missions where large amounts of electrical power will be required. Although it is primarily intended for unmanned spacecraft, it can be adapted to a manned space platform by tethering it above the station through an electrical transmission line which isolates the reactor far away from the inhabited platform and conveys its power back to where it is needed. The transmission line, used in conjunction with an instrument rate shield, attenuates reactor radiation in the vicinity of the space station to less than one-one hundredth of the natural background which is already there. This combination of shielding and distance attenuation is less than one-tenth the mass of boom-mounted or onboard man-rated shields that are required when the reactor is mounted nearby. This paper describes how connection is made to the platform (configuration, operational requirements) and introduces a new element the coaxial transmission tube which enables efficient transmission of electrical power through long tethers in space. Design methodology for transmission tubes and tube arrays is discussed. An example conceptual design is presented that shows SP-100 at three power levels 100 kWe, 300 kWe, and 1000 kWe connected to space station via a 2 km HVDC transmission line/tether. Power system performance, mass, and radiation hazard are estimated with impacts on space station architecture and operation. B.W.

N85-28222*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

PERFORMANCE ANALYSIS OF RADIATION COOLED DC TRANSMISSION LINES FOR HIGH POWER SPACE SYSTEMS

G. E. SCHWARZE 1985 32 p refs Prepared for presentation at the 20th Intersoc. Energy Conversion Eng. Conf., Miami Beach, Fla., 18-23 Aug. 1985; sponsored in part by SAE, ANS, ASME, IEEE, AIAA, ACS and AIChE

(NASA-TM-87040; E-2596; NAS 1.15:87040) Avail: NTIS HC A03/MF A01 CSCL 09C

As space power levels increase to meet mission objectives and also as the transmission distance between power source and load increases, the mass, volume, power loss, and operating voltage and temperature become important system design considerations. This analysis develops the dependence of the specific mass and percent power loss on hte power and voltage levels, transmission distance, operating temperature and conductor material properties. Only radiation cooling is considered since the transmission line is assumed to operate in a space environment. The results show that the limiting conditions for achieving low specific mass, percent power loss, and volume for a space-type dc transmission line are the permissible transmission voltage and operating temperature. Other means to achieve low specific mass include the judicious choice of conductor materials. The results of this analysis should be immediately applicable to power system trade-off studies including comparisons with ac transmission systems. Author

N85-31139*# Lockheed Missiles and Space Co., Sunnyvale, Calif.
MULTI-KW SOLAR ARRAYS FOR EARTH ORBIT APPLICATIONS *Final Report*
Jun. 1985 62 p
(Contract NAS8-36162)
(NASA-CR-171538; NAS 1.26:171538; LMSC-D973456) Avail: NTIS HC A04/MF A01 CSCL 10A

The multi-kW solar array program is concerned with developing the technology required to enable the design of solar arrays required to power the missions of the 1990's. The present effort required the design of a modular solar array panel consisting of superstrate modules interconnected to provide the structural support for the solar cells. The effort was divided into two tasks: (1) superstrate solar array panel design, and (2) superstrate solar array panel-to-panel design. The primary objective was to systematically investigate critical areas of the transparent superstrate solar array and evaluate the flight capabilities of this low cost approach. G.L.C.

N85-31371*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
THE 1984 GODDARD SPACE FLIGHT CENTER BATTERY WORKSHOP
G. W. MORROW, ed. Washington Jul. 1985 592 p refs *Workshop held in Greenbelt, Md., 13-15 Nov. 1984*
(Contract NASA ORDER S-14764-D)
(NASA-CP-2382; REPT-85B0328; NAS 1.55:2382) Avail: NTIS HC A25/MF A01 CSCL 10C

Various topics related to spacecraft power supply systems are discussed. Regenerative fuel cells, lithium molybdenum batteries, nickel hydrogen batteries, nickel cadmium batteries, failure analysis, and performance testing are covered.

N85-31372*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
REGENERATIVE FUEL CELL SYSTEMS FOR SPACE STATION
M. A. HOBERECHT and D. W. SHEIBLEY *In* NASA. Goddard Space Flight Center The 1984 Goddard Space Flight Center Battery Workshop p 21-29 Jul. 1985
Avail: NTIS HC A25/MF A01 CSCL 10A

Regenerative fuel cell (RFC) systems are the leading energy storage candidates for Space Station. Key design features are the advanced state of technology readiness and high degree of system level design flexibility. Technology readiness was demonstrated through testing at the single cell, cell stack, mechanical ancillary component, subsystem, and breadboard levels. Design flexibility characteristics include independent sizing of power and energy storage portions of the system, integration of common reactants with other space station systems, and a wide range of various maintenance approaches. The design features led to selection of a RFC system as the sole *electrochemical energy storage technology option for the space* station advanced development program. E.A.K.

N85-31374*# *National Aeronautics and Space Administration.* Lewis Research Center, Cleveland, Ohio.
SOLAR DYNAMIC SYSTEMS
M. O. DUSTIN *In* NASA. Goddard Space Flight Center The 1984 Goddard Space Flight Center Battery Workshop p 53-68 Jul. 1985
Avail: NTIS HC A25/MF A01 CSCL 10A

The development of the solar dynamic system is discussed. The benefits of the solar dynamic system over pv systems are enumerated. The history of the solar dynamic development is recounted. The purpose and approach of the advanced development are outlined. Critical concentrator technology and critical heat recover technology are examined. E.A.K.

N85-31624*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
HIGH EFFICIENCY SOLAR CELL RESEARCH FOR SPACE APPLICATIONS
D. J. FLOOD *In* JPL Proc. of the Flat-Plate Solar Array Proj. Res. Forum on High-Efficiency Crystalline Silicon Solar Cells p 147-162 15 May 1985 refs
Avail: NTIS HC A21/MF A01 CSCL 10A

A review is given of NASA photovoltaic research with emphasis on the activities of the Lewis Research Center. High efficiency solar cell research is discussed, as well as solar arrays, multi-junction cell bandgaps, and plasmon coupling. R.J.F.

N85-31654# Societe Nationale Industrielle Aerospatiale, Cannes (France).
RETRACTABLE RIGID SOLAR GENERATOR (GSR)
P. BOBO 1985 7 p refs Presented at 4th Symp. Europeene de Generateurs Photovoltaiques Spatiaux, Cannes, France, 18 Nov. 1984
(SNIAS-851-440-101) Avail: NTIS HC A02/MF A01

A retractable rigid 6 kW solar array is described. The deployment-retraction system uses a pantograph with retraction ensured by an electric motor pulling a cable fixed to the outermost panel. Panel structure is similar to TV-SAT, but with wrapped rather than woven carbon fibers. Extension to 10 kW appears feasible. Author (ESA)

N85-31656# Societe Nationale Industrielle Aerospatiale, Cannes (France).
THE SPOT SOLAR ARRAY
R. KRAWCZYK and L. DECRAMER (CNES, Toulouse) 1985 11 p Presented at 4th Symp. Europeene de Generateurs Photovoltaiques Spatiaux, Cannes, France, 18 Nov. 1984
(SNIAS-851-440-103) Avail: NTIS HC A02/MF A01

The SPOT (French satellite) double deployment direction flexible fold-out solar array is described. Its power can be adapted between 1 and 1.8 kW after 2 yr in low orbit. The mass = 154 kg. The spring loaded deployment system is illustrated. The pantographs, stowage box, and solar skins are shown. Possible performance improvements are indicated. Author (ESA)

N85-34175*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
SOLAR MAXIMUM: SOLAR ARRAY DEGRADATION
T. MILLER Aug. 1985 20 p refs
(NASA-TM-86194; REPT-85B0257; NAS 1.15:86194) Avail: NTIS HC A02/MF A01 CSCL 10B

The 5-year in-orbit power degradation of the silicon solar array aboard the Solar Maximum Satellite was evaluated. This was the first spacecraft to use Teflon R FEP as a coverglass adhesive, thus avoiding the necessity of an ultraviolet filter. The peak power *tracking mode of the power regulator unit was employed to ensure* consistent maximum power comparisons. Telemetry was normalized to account for the effects of illumination intensity, charged particle irradiation dosage, and solar array temperature. Reference conditions of 1.0 solar constant at air mass zero and 301 K (28 C) were used as a basis for normalization. Beginning-of-life array power was 2230 watts. Currently, the array output is 1830 watts. This corresponds to a 16 percent loss in array performance over 5 years. Comparison of Solar Maximum Telemetry and predicted power levels indicate that array output is 2 percent less than predictions based on an annual 1.0 MeV equivalent election fluence of 2.34 x ten to the 13th power square centimeters space environment. Author

N85-34176*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
OPTICAL ANALYSIS OF PARABOLIC DISH CONCENTRATORS FOR SOLAR DYNAMIC POWER SYSTEMS IN SPACE
K. S. JEFFERIES Aug. 1985 27 p refs
(NASA-TM-87080; E-2659; NAS 1.15:87080) Avail: NTIS HC A03/MF A01 CSCL 10B

An optical analysis of a parabolic solar collection system operating in Earth orbit was performed using ray tracing techniques. The analysis included the effects of: (1) solar limb darkening, (2) parametric variation of mirror surface error, (3) parametric variation of mirror rim angle, and (4) parametric variation of alignment and pointing error. This ray tracing technique used numerical integration to combine the effects of rays emanating from different parts of the sun at different intensities with the effects of normally distributed mirror-surface errors to compute the angular intensity distribution of rays leaving the mirror surface. A second numerical integration was then performed over the surface of the parabolic mirror to compute the radial distribution of brightness at the mirror focus. Major results of the analysis included: (1) solar energy can be collected at high temperatures with high efficiency, (2) higher absorber temperatures can be achieved at lower efficiencies, or higher efficiencies can be achieved at lower temperatures, and (3) collection efficiency is near its maximum level across a broad plateau of rim angles from 40 deg to 70 deg. Author

N85-34442*# Astro Aerospace Corp., Carpinteria, Calif.
STACBEAM 2 Final Report
L. R. ADAMS and A. VONROOS 23 Apr. 1985 61 p refs
Prepared in cooperation with JPL, Pasadena, Calif.
(NASA-CR-176126; JPL-9950-1159; NAS 1.26:176126; AAC-TN-1134) Avail: NTIS HC A04/MF A01 CSCL 10B

An investigation being conducted by Astro Aerospace Corporation (Astro) for Jet Propulsion Laboratory in which efficient structures for geosynchronous spacecraft solar arrays are being developed is discussed. Recent developments in solar blanket technology, including the introduction of ultrathin (50 micrometer) silicon solar cells with conversion efficiencies approaching 15 percent, have resulted in a significant increase in blanket specific power. System specific power depends not only on blanket mass but also on the masses of the support structure and deployment mechanism. These masses must clearly be reduced, not only to minimize launch weight, but also to increase array natural frequency. The solar array system natural frequency should be kept high in order to reduce the demands on the attitude control system. This goal is approached by decreasing system mass, by increasing structural stiffness, and by partitioning the blanket. As a result of this work, a highly efficient structure for deploying a solar array was developed. R.F.J.

N85-35728*# Boeing Aerospace Co., Seattle, Wash. Electrical Power Systems Technology.
APPLICABILITY OF 100KWE-CLASS OF SPACE REACTOR POWER SYSTEMS TO NASA MANNED SPACE STATION MISSIONS Final Report
S. W. SILVERMAN, H. J. WILLENBERG, and C. ROBERTSON (General Electric Co., King of Prussia, Pa.) Aug. 1985 184 p refs
(Contract NAS3-23865)
(NASA-CR-174696; NAS 1.26:174696; D180-28461-1) Avail: NTIS HC A09/MF A01 CSCL 18I

An assessment is made of a manned space station operating with sufficiently high power demands to require a multihundred kilowatt range electrical power system. The nuclear reactor is a competitor for supplying this power level. Load levels were selected at 150kWe and 300kWe. Interactions among the reactor electrical power system, the manned space station, the space transportation system, and the mission were evaluated. The reactor shield and the conversion equipment were assumed to be in different positions with respect to the station; on board, tethered, and on a free flyer platform. Mission analyses showed that the free flyer concept resulted in unacceptable costs and technical problems. The tethered reactor providing power to an electrolyzer for regenerative fuel cells on the space station, results in a minimum weight shield and can be designed to release the reactor power section so that it moves to a high altitude orbit where the decay period is at least 300 years. Placing the reactor on the station, on a structural boom is an attractive design, but heavier than the long tethered reactor design because of the shield weight for manned activity near the reactor. Author

08

ELECTRONICS

Includes descriptions of analytical techniques, analyses, systems, and requirements for internal and external communications, electronics, sensors for position and systems monitoring and antennas.

A85-32176
NTC '83; PROCEEDINGS OF THE NATIONAL TELESYSTEMS CONFERENCE, SAN FRANCISCO, CA, NOVEMBER 14-16, 1983
Conference sponsored by the Institute of Electrical and Electronics Engineers. New York, Institute of Electrical and Electronics Engineers, Inc., 1983, 444 p. For individual items see A85-32177 to A85-32233.

Among the topics discussed are NASA Space Station fiber-optics technology,multifrequency L-band adaptive nulling, the evaluation of radome materials, spaceborne multifunction imaging radar antenna development, microwave receiver technology for space systems, system applications for SAW devices, mutually synchronized oscillators, radiation-hardened bulk CMOS technology for space and weapons systems, advances in CMOS-SOS integrated circuits, multiaccess protocols for processing satellite communications systems, the application of the Global Positioning System (GPS) to geodesy, the contrast enhancement of Landsat 4 Thematic Mapper data, and GPS-based weapons delivery. Also discussed are low cost GPS receiver designs, GPS altitude determination, GPS equipment for test range applications, TDMA differential GPS, a GPS fast acquisition receiver, trajectory estimation on the basis of GPS translated signals, the handling of high dimensionality data, a Space Shuttle imaging spectrometer experiment, advances in communication satellite systems (Inmarsat and Intelsat), NASA space commercialization programs, and an advanced earth observation spacecraft. O.C.

A85-32177* Rice Univ., Houston, Tex.
APPLICATIONS OF FIBER OPTICS TECHNOLOGY TO THE SPACE STATION
H. O. ERWIN (NASA, Johnson Space Center, Houston, TX), T. A. RABSON (Rice University, Houston, TX), and M. B. DAETWYLER (NASA, Johnson Space Center; Rice University, Houston, TX) IN: NTC '83; Proceedings of the National Telesystems Conference, San Francisco, CA, November 14-16, 1983 . New York, Institute of Electrical and Electronics Engineers, Inc., 1983, p. 1-5. refs

Attention is given to the EM interference, data bandwidth requirement, zero gravity operation, data security, crew safety, and modular expansion considerations affecting the future design of fiber-optical systems for large manned orbiting stations. Emphasis is given to replacing current, solar cell array electric systems technology for onboard furnace operation, leading to the formulation of a concentrated solar energy (thermal IR) transport system that yields higher efficiency than photovoltaics, despite its lower weight, in conjunction with Brayton, Rankine or Stirling cycle engines. The optical characteristics of the optical fibers employed by this system are discussed. O.C.

A85-32228*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
A CONCEPT FOR AN ADVANCED EARTH OBSERVATION SPACECRAFT
U. M. LOVELACE (NASA, Langley Research Center, Hampton, VA) IN: NTC '83; Proceedings of the National Telesystems Conference, San Francisco, CA, November 14-16, 1983 . New York, Institute of Electrical and Electronics Engineers, Inc., 1983, p. 384-391.

Remote sensing missions have been synthesized which could contribute significantly to the understanding of global environmental parameters. Instruments capable of sensing important land and sea parameters are combined with a large antenna designed to passively quantify surface emitted radiation at several wavelengths. A conceptual design for this large deployable antenna has been developed. All subsystems required to make the antenna an autonomous spacecraft have been conceptually designed. The entire package, including necessary orbit transfer propulsion, is folded to package within the Space Transportation System (STS) cargo bay. After separation the antenna, its integral feed mast, radiometer receivers, power system, and other instruments are automatically deployed and transferred to the operational orbit. The design resulted in an antenna with a major antenna dimension of 120 meters, weighting 7650 kilograms, and operating at an altitude of 700 kilometers. Author

N85-23815*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
ALTERNATIVES FOR SATELLITE SOUND BROADCAST SYSTEMS AT HF AND VHF
B. E. LEROY *In* NASA. Langley Research Center Large Space Antenna Systems Technol., 1984 p 27-37 Apr. 1985
Avail: NTIS HC A20/MF A01 CSCL 20N

The National Aeronautics and Space Administration and the United States Information Agency (USIA) are currently engaged in a joint program to assess the technical and economic feasibility of direct sound broadcast satellite systems to meet USIA mission needs. The cooperative effort calls for a series of interrelated studies to provide the respective Agency managements with information on the potential role of direct broadcast satellites. Initial studies focused on HF propagation phenomena and broadcast coverage requirements. These studies served as the basis for parallel systems studies currently in progress. The systems studies are to provide a data base on various satellite configurations and systems concepts capable of supporting potential broadcast requirements ranging from a small fraction to a substantial addition to USIA requirements. Antenna concepts for LEO and GEO orbits are briefly described. M.G.

N85-26849*# Ford Aerospace and Communications Corp., Palo Alto, Calif.
SPACECRAFT CONFIGURATION STUDY FOR SECOND GENERATION MOBILE SATELLITE SYSTEM Final Report
M. LOUIE, W. VONSTENTZSCH, F. ZANELLA, R. HAYES, F. MCGOVERN, and R. TYNER Jan. 1985 111 p refs
(Contract JPL-956904)
(NASA-CR-175774; JPL-9950-1086; NAS 1.26:175774) Avail: NTIS HC A06/MF A01 CSCL 22B

A high power, high performance communicatons satellite bus being developed is designed to satisfy a broad range of multimission payload requirements in a cost effective manner and is compatible with both STS and expendable launchers. Results are presented of tradeoff studies conducted to optimize the second generation mobile satellite system for its mass, power, and physical size. Investigations of the 20-meter antenna configuration, transponder linearization techniques, needed spacecraft modifications, and spacecraft power, dissipation, mass, and physical size indicate that the advanced spacecraft bus is capable of supporting the required payload for the satellite. A.R.H.

09

PROPULSION

Includes descriptions, analyses, and subsystem requirements for propellant storage and destribution, and propulsion systems for attitude control and orbit maintenance and transfer for the station and supporting elements such as the OMV and OTV.

A85-33765
THERMODYNAMIC BEHAVIOR OF COLD GAS SYSTEM FOR THE ATTITUDE CONTROL OF TETHERED SATELLITE
B. BERRUTI, G. BORRIELLO, and C. CHIARELLI (Aeritalia S.p.A., Turin, Italy) AIAA, SAE, ASME, AIChE, and ASMA, Intersociety Conference on Environmental Systems, 14th, San Diego, CA, July 16-19, 1984. 11 p. refs
(SAE PAPER 840954)

Nitrogen gas temperature profiles during all the phases of the Tethered Satellite mission have been predicted. The evaluation of the heat transfer coefficient between the tank and the gas is the leading parameter for the computation of such temperature history. It has been demonstrated that a good coupling with the satellite environment and an external power source are necessary to maintain the gas and the Auxiliary Propulsion Subsystem (APS) component's temperature within acceptable limits and to fulfill the total impulse requirement. Author

A85-39587#
PULSED PLASMA THRUSTERS FOR ORBIT TRANSFER
P. J. TURCHI (R&D Associates, Alexandria, VA) Journal of Propulsion and Power (ISSN 0748-4658), vol. 1, July-Aug. 1985, p. 313, 314. Previously cited in issue 17, p. 2442, Accession no. A84-36974. refs

A85-39626*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
SPACE STATION PROPULSION - THE ADVANCED DEVELOPMENT PROGRAM AT LEWIS
R. E. JONES (NASA, Lewis Research Center, Cleveland, OH) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 21st, Monterey, CA, July 8-10, 1985. 9 p. Previously announced in STAR as N85-25386.
(AIAA PAPER 85-1154)

A reference configuration was established for the initial operating capability (IOC) station. The reference configuration has assumed hydrazine fueled thrusters as the propulsion system. This was to establish costing and as a reference for comparison when other propulsion systems are considered. An integral part of the plan to develop the Space Station is the advanced development program. The objective of this program is to provide advanced technology alternatives for the initial and evolutionary Space Station which optimize the system's functional characteristics in terms of performance, cost, and utilization. The portion of the Advanced Development Program that is concerned with auxiliary propulsion and the research and programmatic activities conducted are discussed. E.A.K.

A85-39630*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
PROPULSION EVALUATION FOR ORBIT-ON-DEMAND VEHICLES
J. A. MARTIN, J. C. NAFTEL (NASA, Langley Research Center, Space Systems Div., Hampton, VA), and R. V. TURRIZIANI (Kentron International, Hampton, VA) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 21st, Monterey, CA, July 8-10, 1985. 13 p. refs
(AIAA PAPER 85-1161)

Future earth-to-orbit vehicles may be required to reach orbit within hours or even minutes of a decision. A study has been conducted to consider vehicles with such a capability. In Phase I of the study, 11 vehicles were designed to deploy 5000 lb to a polar orbit. Changes in the designs were examined parametrically

for increased on-orbit maneuvers, increased payload, and other mission variations. Based on the results, two concepts were selected for Phase II design work: a vertical-takeoff, two-stage system and a horizontal-takeoff, two-stage system with an airbreathing subsonic first stage. The results of several propulsion evaluations are presented, including liftoff thrust-to-weight effects, dual-fuel propulsion for a horizontal-takeoff concept, and the effect of using fluorine. Author

A85-39666#
SUPPLYING CRYOGENIC PROPELLANTS FOR SPACE BASED OTV
W. L. GILMORE (Martin Marietta Aerospace, Michoud Div., New Orleans, LA) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 21st, Monterey, CA, July 8-10, 1985. 11 p.
(AIAA PAPER 85-1225)

Since the propellant costs will be up to 85 percent of the program costs of an OTV, scavenging the STS external tank (ET) is a potential cost-saving measure. The OTV would be transported to space in an aft-cargo carrier on the stern of the ET. The ET residual fuel sometimes totals 10 tons, and can be drained into on-orbit or Space Station storage facilities. A special vehicle would be dedicated to the scavenging process. All the concepts are considered not ideal because the ET would have to be taken into orbit for the scavenging, then deorbited for removal. It would be necessary to pump an inert gas into the ET reservoirs to force out the residuals, a process that has been tested on the ground. M.S.K.

A85-39670#
PROPELLANT MANAGEMENT IN TOROIDAL TANKS
S. M. DOMINICK and J. R. TEGART (Martin Marietta Aerospace, Propulsion Section, Denver, CO) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 21st, Monterey, CA, July 8-10, 1985. 9 p. refs
(AIAA PAPER 85-1231)

The results of a propellant management study applied to a cryogenic toroidal tank OTV are reported. A toroidal geometry for containment of the oxidizer offers a more efficient geometry of STS bay storage, and therefore more payload space. Toroidal tanks present problems in the control of the position of the liquid and efficient draining. Tests have been performed with total capillary communication, which would assess the delivery of only gas-free fuel to the thruster, trap devices to hold propellant available for engine start, and propulsive settling configurations to move fuel to a position over the tank outlet before each firing. Test results from bare, four- and eight-baffled toroidal tanks are discussed. M.S.K.

A85-39730*# Martin Marietta Aerospace, Denver, Colo.
MAIN PROPULSION SYSTEM DESIGN RECOMMENDATIONS FOR AN ADVANCED ORBIT TRANSFER VEHICLE
L. REDD (Martin Marietta Aerospace, Denver, CO) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 21st, Monterey, CA, July 8-10, 1985. 9 p.
(Contract NAS3-23858)
(AIAA PAPER 85-1336)

Various main propulsion system configurations of an advanced OTV are evaluated with respect to the probability of nonindependent failures, i.e., engine failures that disable the entire main propulsion system. Analysis of the life-cycle cost (LCC) indicates that LCC is sensitive to the main propulsion system reliability, vehicle dry weight, and propellant cost; it is relatively insensitive to the number of missions/overhaul, failures per mission, and EVA and IVA cost. In conclusion, two or three engines are recommended in view of their highest reliability, minimum life-cycle cost, and fail operational/fail safe capability. L.T.

A85-39732#
RL10 DERIVATIVE ENGINES FOR THE OTV
R. R. FOUST (United Technologies Corp., Engineering Div., West Palm Beach, FL) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 21st, Monterey, CA, July 8-10, 1985. 11 p.
(AIAA PAPER 85-1338)

Derivative RL10 engines can satisfy the main propulsion requirements for the Orbital Transfer Vehicle (OTV) while offering a low risk minimum cost development program. The RL10 Product Improvement Program (PIP) is producing the technology for improving this engine through addition of multi-mode thrust, high mixture ratio capability and extendible nozzles. These features which have already been proven in concept in the PIP when added to the proven RL10 capability and reliability make this engine an outstanding candidate for OTV propulsion. Subjective factors for reusable rocket engines, influenced by Pratt & Whitney gas turbine engine experience, provide insights into reliability, engine life, maintenance and health monitoring; often varying from seemingly obvious conclusions. The RL10 Product Improvement Program is being conducted by Pratt & Whitney under NASA's Lewis Research Center contracts NAS3-22902 and NAS3-24238. Author

A85-39734#
SYSTEM REQUIREMENTS IMPACT ON ADVANCED OTV ENGINE DESIGN
J. R. BROWN (United Technologies Corp., Engineering Div., West Palm Beach, FL) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 21st, Monterey, CA, July 8-10, 1985. 5 p. refs
(AIAA PAPER 85-1340)

Cryogenic vehicles for orbit transfer have been under study since 1970. During the decade of the 70's the studies emphasized a Shuttle compatible, ground based vehicle. The topics of man-rating and aeroassisted return from GEO were addressed in the 1980 OTV Concept Definition Study. Based on the requirements of these studies for an advanced engine, Pratt and Whitney designed the advanced expander cycle engine for a high performance OTV. Subsequently a number of issues, such as geometric constraints, man-rating criteria and serviceability, were raised concerning the suitability of such an engine in view of changing requirements. Several recent studies by vehicle systems contractors have resolved some of these issues and Pratt and Whitney has evolved its advanced engine design to meet currently desired operational characteristics. The paper traces this propulsion design evolution and indicates potential future impacts to engine design criteria. Author

A85-39735*# Aerojet Techsystems Co., Sacramento, Calif.
PROGRESS REPORT - ADVANCED CRYOGENIC OTV ENGINE TECHNOLOGY
L. SCHOENMAN (Aerojet TechSystems Co., Sacramento, CA) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 21st, Monterey, CA, July 8-10, 1985. 11 p. refs
(Contract NAS3-23772)
(AIAA PAPER 85-1341)

New technologies for space-based, reusable, throttleable, cryogenic orbit transfer propulsion are being evaluated. A variable-thrust (200 to 3000 lbF), 2000 psi chamber pressure, LO2/LH2 engine has been selected to demonstrate the 20-hour, 500-restart life goal, and a specific impulse in excess of 480 lbF-sec/lbM. The results of recent vehicle-engine integration analyses and the progress in design, fabrication, and testing are provided. Emphasis is placed on the following technology areas being investigated in support of the advanced engine design: LOX hydrostatic bearings; burn-resistant materials for high-pressure GOX turbines and valves; high surface-low flux annular combustion chambers for the dual propellant expander cycle; improved cooling approaches for high-pressure combustion chambers, new concepts in integrated controls; and engine health diagnostics. Author

A85-39745#
THE LAUNCH LOOP - A LOW COST EARTH-TO-HIGH-ORBIT LAUNCH SYSTEM
K. H. LOFSTROM AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 21st, Monterey, CA, July 8-10, 1985. 15 p. refs
(AIAA PAPER 85-1368)

The Launch Loop is an earth surface based launching utility that stores energy and momentum in a very long, small cross-section iron ribbon loop moving at high velocity. The downward forces necessary to deflect the ribbon from its otherwise straight path support a magnetically levitated track system, control cables, and vehicles at high altitudes against gravity. This paper presents a preliminary system that can launch five metric ton vehicles to geosynchronous or near-lunar orbits at rates of up to 80 per hour. Author

A85-39760#
PREDICTED POST BURN RESIDUAL THRUST FOR AN ORBITAL TRANSFER MOTOR
S. BORAAS, B. HYLAND, and L. SMART (Morton Thiokol, Inc., Wasatch Div., Brigham City, UT) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 21st, Monterey, CA, July 8-10, 1985. 9 p. refs
(AIAA PAPER 85-1395)

A technique for predicting the magnitude and the duration of post-burn residual thrust for an orbital transfer motor (OTM) is developed and discussed. Three existing predictive methods, used to arrive at the mixture properties within the motor near and subsequent to motor burnout for which a one-dimensional thrust calculation is made, are described. The predicted values of chamber pressure for a spinning OTM compare favorably with pressure measurements obtained at the Arnold engineering development center, thus confirming that the deposited slag is the primary heat source for the pyrolytic action and that the developed technique is viable. M.D.

A85-39800#
ORBIT TRANSFER WITH HIGH POWER MPD THRUSTERS
L. K. RUDOLPH and G. M. OGG (Martin Marietta Aerospace, Denver, CO) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 21st, Monterey, CA, July 8-10, 1985. 11 p. refs
(Contract F04611-82-C-0049)
(AIAA PAPER 85-1478)

A comparison study between advanced LO2/LH2 chemical-propelled orbit transfer vehicles (OTV) and argon-fueled MPD thruster OTVs has been completed. The study considered low earth to geosynchronous orbit transfer of payload masses up to 200,000 kg, and was based on technology extrapolations to the early 21st century. Argon MPD thruster OTV power levels from 0.5 to 10 MWe were considered with thrust efficiencies from 0.5 to 0.7. Results indicate expendable MPD thruster OTVs do not compare favorably with chemical OTVs. Reusable or payload-powered MPD thruster OTVs can deliver payloads of over 10,000 kg at a cost less than half that of advanced chemical OTV systems. Author

A85-40676*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
LASER PROPULSION FOR ORBIT TRANSFER - LASER TECHNOLOGY ISSUES
J. C. HORVATH and R. H. FRISBEE (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) American Institute of Aeronautics and Astronautics, Fluid Dynamics and Plasmadynamics and Lasers Conference, 18th, Cincinnati, OH, July 16-18, 1985. 6 p. NASA-supported research. refs
(AIAA PAPER 85-1550)

Using reasonable near-term mission traffic models (1991-2000 being the assumed operational time of the system) and the most current unclassified laser and laser thruster information available, it was found that space-based laser propulsion orbit transfer vehicles (OTVs) can outperform the aerobraked chemical OTV over a 10-year life-cycle. The conservative traffic models used resulted in an optimum laser power of about 1 MW per laser. This is significantly lower than the power levels considered in other studies. Trip time was taken into account only to the extent that the system was sized to accomplish the mission schedule. Author

A85-40823*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
LASER PROPULSION FOR THE ORBITAL TRANSFER MISSION
R. H. FRISBEE, J. C. HORVATH, and J. C. SERCEL (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 21st, Monterey, CA, July 8-10, 1985. 15 p. NASA-supported research. refs
(AIAA PAPER 85-1224)

America's space activities in the 1990s and beyond will partly consist of missions involving the transportation of cargo from low earth orbit (LEO) to higher orbits or to an escape trajectory. Such missions are to be performed with the aid of an orbit transfer vehicle (OTV). The operation of the OTV can be based on different propulsion concepts. A chemical OTV is characterized by a high thrust and low specific impulse. The result is a short trip time at the cost of large quantities of propellant. On the other hand, low-thrust systems such as electric propulsion units, consume very little propellant, but would have a long trip time. The present paper is concerned with a compromise between these two extremes. The employed propulsion system utilizes laser thermal propulsion, in which a ground or space-based laser is used to beam energy to a thruster on the OTV. The laser light is absorbed by a propellant. The resulting heating of the propellant causes an expansion of the propellant through a nozzle to produce thrust. Details regarding this propulsion concept are discussed, taking into account operational questions and missions. G.R.

A85-40825#
ORBITAL FLUID MANAGEMENT
R. N. EBERHARDT and D. A. FESTER (Martin Marietta Aerospace, Denver, CO) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 21st, Monterey, CA, July 8-10, 1985. 20 p. refs
(AIAA PAPER 85-1234)

Fluid management in space is required for Space Station, Orbit Maneuvering Vehicles, Orbit Transfer Vehicles, military systems, scientific payloads, and applications and research satellites. Dedicated resupply tankers and propellant scavenging from Shuttle tanks are means for resupplying space-based systems. With the advent of Space Station, attached, free-flying or tethered depots provide on-orbit storage from which user systems can be serviced. An operational scenario is presented which begins with loading and launch of a resupply tanker, the transfer of fluid to a space-based depot and the resupply of a space-based user system from the depot. Both storable and cryogenic fluid management technologies for liquid storage/supply, thermal control and fluid transfer/resupply are identified considering space-based operations. Pertinent requirements and operations issues are addressed, including life, complexity of designs and operations, degradation, reusability, mission suitability, system interface impacts and operational limitations. An overall orbital fluid management capability assessment is provided. The status of technologies is addressed, considering ground testing, low-g drop tower or KC-135 aircraft testing, flight demonstrations and flight qualified systems. Experimental fluid management test beds proposed for obtaining low-g technology data not presently available for incorporation into system designs are discussed relative to filling the technology gaps. Author

A85-41857
LASER PROPULSION TEST ONBOARD SPACE STATION
T. ABE and K. KURIKI (Tokyo, University, Japan) (University of Tokyo and Ministry of Education, Science, and Culture, Space Energy Symposium, 3rd, Tokyo, Japan, Mar. 26, 1984) Space Solar Power Review (ISSN 0191-9067), vol. 5, no. 2, 1985, p. 121-125.

A laser propulsion system (LAPS) to be tested on board the Shuttle is described. The basic design features of the LAPS are

described, and recommendations are offered with respect to the optimum type of laser radiation (CO2); input power (30 kW); and the design of the LAPS thruster. The LAPS is considered to be a candidate propulsion system for the Orbital Transfer Vehicle (OTV). A schematic of the LAPS is presented showing both a single port and two port engine configurations. I.H.

A85-41867
ADVANCED SCHEME OF CO2 LASER FOR SPACE PROPULSION
K. MAENO (Muroran Institute of Technology, Japan) (University of Tokyo and Ministry of Education, Science, and Culture, Space Energy Symposium, 3rd, Tokyo, Japan, Mar. 26, 1984) Space Solar Power Review (ISSN 0191-9067), vol. 5, no. 2, 1985, p. 207-211. refs

An improved scheme of CO2 mixing laser with glow discharge is investigated for the purpose of laser propulsion experiments utilizing a solar cell array on the Space Station. The analyzed characteristics of this CO2 mixing laser show favorable results without catalyst He, which corresponds to the distributions of measured small signal gain coefficient in our fundamental experiments. While employing this improved scheme of CO2 laser, the specific features of space laser propulsion experiment in the 1990s are studied. Author

A85-41868
ELECTRIC PROPULSION TEST ONBOARD THE SPACE STATION
Y. NAKAMURA (National Aerospace Laboratory, Chofu, Japan) and K. KURIKI (Tokyo, University, Japan) (University of Tokyo and Ministry of Education, Science, and Culture, Space Energy Symposium, 3rd, Tokyo, Japan, Mar. 26, 1984) Space Solar Power Review (ISSN 0191-9067), vol. 5, no. 2, 1985, p. 213-219.

The electric propulsion system of high specific impulse will be necessarily one of the most useful cargo orbit transfer vehicles in future expanding space activities. Testings of high power electric propulsion systems (MPD and ion thrusters) onboard the Space Station and/or a free flyer (Bus Platform) away from the station are planned to demonstrate the feasibilities of the propulsion systems and to observe the interference of thruster plasma exhaust with the spacecraft and the ionospheric environment. It is of great advantage in reliability as well as cost, to conduct long-term tests of such thrusters in space that exhaust significant rate of ionized and non-condensable propellant. Several flight modes of the Platform in the proximity of, and in the long distance from, the Space Station are described to verify the produced thrusts and to monitor the plasma plume in the geomagnetic field. Author

A85-42922*# Xerox Electro-Optical Systems, Pasadena, Calif.
DEVELOPMENT OF A LARGE INSERT GAS ION THRUSTER
G. STEINER (Xerox Electro-Optical Systems, Pasadena, CA) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 22, July-Aug. 1985, p. 465-468. Previously cited in issue 02, p. 146, Accession no. A83-12496. refs
(Contract NAS3-22444)

A85-43975*# Boeing Aerospace Co., Seattle, Wash.
SPACE STATION PROPULSION OPTIONS
C. L. WILKINSON, S. M. BRENNAN (Boeing Aerospace Co., Seattle, WA), and M. E. VALGORA (NASA, Lewis Research Center, Cleveland, OH) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 21st, Monterey, CA, July 8-10, 1985. 9 p. refs
(Contract NAS3-23353)
(AIAA PAPER 85-1155)

The selection of the propulsion system for the Space Station represents a complex issue. The present paper provides a summary of the Station design factors which dictate the propulsion requirements, taking into account approaches for meeting these requirements. Factors which affect propulsion system selection are related to thrusting strategy, volume and mass limitations, safety and contamination, electrical power, time phasing, synergistic opportunities, propellant scavenging, water electrolysis, and free-flyers. In a discussion of propulsion systems, attention is given to monopropellant options, bipropellant options, and resistojets. G.R.

A85-43976*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
AN EVALUATION OF OXYGEN/HYDROGEN PROPULSION SYSTEMS FOR THE SPACE STATION
R. W. KLEMETSON, P. W. GARRISON (California Institute of Technology, Jet Propulsion Laboratory, Pasadena), and N. P. HANNUM (NASA, Lewis Research Center, Cleveland, OH) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 21st, Monterey, CA, July 8-10, 1985. 27 p. NASA-supported research. Previously announced in STAR as N85-28971. refs
(AIAA PAPER 85-1156)

Conceptual designs for O2/H2 chemical and resistojet propulsion systems for the Space Station was developed and evaluated. The evolution of propulsion requirements was considered as the Space Station configuration and its utilization as a space transportation node change over the first decade of operation. The characteristics of candidate O2/H2 auxiliary propulsion systems are determined, and opportunities for integration with the OTV tank farm and the Space Station life support, power and thermal control subsystems are investigated. OTV tank farm boiloff can provide a major portion of the growth station impulse requirements and CO2 from the life support system can be a significant propellant resource, provided it is not denied by closure of that subsystem. Waste heat from the thermal control system is sufficient for many propellant conditioning requirements. It is concluded that the optimum level of subsystem integration must be based on higher level Space Station studies. Author

N85-22520*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
PRELIMINARY ASSESSMENT OF POWER-GENERATING TETHERS IN SPACE AND OF PROPULSION FOR THEIR ORBIT MAINTENANCE
R. E. ENGLISH and P. M. FINNEGAN *In its* Spacecraft Environ. Interactions Technol., 1983 p 637-647 Mar. 1985 refs
Avail: NTIS HC A99/MF E03 CSCL 22B

The concept of generating power in space by means of a conducting tether deployed from a spacecraft was studied. Using hydrogen and oxygen as the rocket propellant to overcome the drag of such a power-generating tether would yield more benefit than if used in a fuel cell. The mass consumption would be 25 percent less than the reactant consumption of fuel cells. Residual hydrogen and oxygen in the external tank and in the orbiter could be used very effectively for this purpose. Many other materials (such as waste from life support) could be used as the propellant. Electrical propulsion using tether generated power can compensate for the drag of a power-generating tether, half the power going to the useful load and the rest for electric propulsion. In addition, the spacecraft's orbital energy is a large energy reservoir that permits load leveling and a ratio of peak to average power equal to 2. Critical technologies to be explored before a power-generating tether can be used in space are delineated. Author

N85-24337*# National Aeronautics and Space Administration, Washington, D.C.
STATION KEEPING OF GEOSTATIONARY SATELLITES BY ELECTRIC PROPULSION
M. C. ECKSTEIN Apr. 1985 43 p refs Transl. into ENGLISH of Conf. Paper from Deut. Ges. fuer Luft- und Raumfahrt, Cologne, DGLR Paper 80-009 43 p Presented at the Walter-Hohmann Symp. uber Raumflugmech., Cologne, 12-13 Mar. 1980 Original language doc. was announced in IAA as A80-41973 Transl. by Scientific Translation Services, Santa Barbara, Calif.
(Contract NASW-4004)
(NASA-TM-77820; NAS 1.15:77820; DGLR-PAPER-80-009)
Avail: NTIS HC A03/MF A01 CSCL 20K

As various types of perturbations tend to drive a geostationary satellite away from its prescribed position, occasional orbit corrections have to be carried out by means of a suitable propulsion system. In future geostationary missions, low thrust electric

propulsion is likely to be applied for station keeping because of considerable mass savings. In this paper a station keeping strategy for electric propulsion systems is developed. Both the unconstrained case and the case where thrust operation constraints are present are considered and tested by computer simulation of a realistic example. Author

N85-25383*# Aerojet Techsystems Co., Sacramento, Calif.
OXYGEN-HYDROGEN THRUSTERS FOR SPACE STATION AUXILIARY PROPULSION SYSTEMS Final Report
D. K. BERKMAN Aug. 1984 109 p refs
(NASA-CR-175691; JPL-9950-974; NAS 1.26:175691; FR-956457-F-1) Avail: NTIS HC A06/MF A01 CSCL 21H

The feasibility and technology requirements of a low-thrust, high-performance, long-life, gaseous oxygen (GO2)/gaseous hydrogen (GH2) thruster were examined. Candidate engine concepts for auxiliary propulsion systems for space station applications were identified. The low-thrust engine (5 to 100 lb sub f) requires significant departure from current applications of oxygen/hydrogen propulsion technology. Selection of the thrust chamber material and cooling method needed or long life poses a major challenge. The use of a chamber material requiring a minimum amount of cooling or the incorporation of regenerative cooling were the only choices available with the potential of achieving very high performance. The design selection for the injector/igniter, the design and fabrication of a regeneratively cooled copper chamber, and the design of a high-temperature rhenium chamber were documented and the performance and heat transfer results obtained from the test program conducted at JPL using the above engine components presented. Approximately 115 engine firings were conducted in the JPL vacuum test facility, using 100:1 expansion ratio nozzles. Engine mixture ratio and fuel-film cooling percentages were parametrically investigated for each test configuration. Author

N85-25385*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
MANRATING ORBITAL TRANSFER VEHICLE PROPULSION
L. P. COOPER 1985 14 p refs Proposed for presentation at the 21st Joint Propulsion Conf., Monterey, Calif., 8-10 Jul. 1985; sponsored by AIAA, SAE and ASME
(NASA-TM-87019; E-2570; NAS 1.15:87019) Avail: NTIS HC A02/MF A01 CSCL 21H

The expended capabilities for Orbital Transfer Vehicles (OTV) which will be needed to meet increased payload requirements for transporting materials and men to geosynchronous orbit are discussed. The requirement to provide manrating offers challenges and opportunities to the propulsion system designers. The propulsion approaches utilized in previous manned space vehicles of the United States are reviewed. The principals of reliability analysis are applied to the Orbit Transfer Vehicle. Propulsion system options are characterized in terms of the test requirements to demonstrate reliability goals and are compared to earlier vehicle approaches. E.A.K.

N85-25386*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
SPACE STATION PROPULSION: THE ADVANCED DEVELOPMENT PROGRAM AT LEWIS
R. E. JONES 1985 14 p refs Proposed for presentation at the 21st Joint Propulsion Conf., Monterey, Calif., 8-10 Jul. 1985; sponsored by AIAA, SAE and ASME
(NASA-TM-86999; E-2544; NAS 1.15:86999) Avail: NTIS HC A02/MF A01 CSCL 21H

A reference configuration was established for the initial operating capability (IOC) station. The reference configuration has assumed hydrazine fueled thrusters as the propulsion system. This was to establish costing and as a reference for comparison when other propulsion systems are considered. An integral part of the plan to develop the Space Station is the advanced development program. The objective of this program is to provide advanced technology alternatives for the initial and evolutionary Space Station which optimize the system's functional characteristics in terms of performance, cost, and utilization. The portion of the Advanced Development Program that is concerned with auxiliary propulsion and the research and programmatic activities conducted are discussed. E.A.K.

N85-26860# Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Engineering.
ANALYSIS OF ORBIT TRANSFER VEHICLES FOR GPS BLOCK 3 SATELLITES M.S. Thesis
D. P. BOYARSKI and S. P. MAHONEY Dec. 1984 194 p
(AD-A152021; AFIT/GSO/OS/84D-2) Avail: NTIS HC A09/MF A01 CSCL 22C

The overall objective of this research was to determine the feasibility and the cost optimum system for using electric OTVs to move Block 3 GPS satellites from LEO to a 10,900 nm orbit. For the EOTV, the propulsion systems considered were present and 1990's technology ion engines using mercury, xenon or argon for a propellant. There were two power sources evaluated, a 100 KW nuclear reactor and solar arrays. A systems cost model which combines payload, power source, trajectory, and earth-to-LEO launch parameters with algorithms characterizing the electric propulsion system was used. The goal was to find the least costly systems which had a triptime equal to or less than 90 days. These systems were than compared with the PAM D-II, CENTAUR-G, and IUS in terms of total deployment costs for 28 GPS satellites launched at a rate of four per year for seven years. The studies found that a reusable EOTV with 12 mercury ion engines powered by gallium arsenide concentrator arrays could perform the mission for 42% of the cost of the cheapest chemical system. The nuclear powered EOTV, while less costly than the chemical systems, was not as competitive as the solar EOTV. The weight of the nuclear reactor and its heat radiators required the use of 37 engines resulting in higher costs for the system. GRA

N85-28971*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
AN EVALUATION OF OXYGEN-HYDROGEN PROPULSION SYSTEMS FOR THE SPACE STATION
R. W. KLEMETSON, P. W. GARRISON, and N. P. HANNUM 1985 28 p refs Presented at the 21st Joint Propulsion Conf., Monterey, Calif., 8-10 Jul. 1985; sponsored in part by AIAA, SAE, ASME, and ASEE Previously announced in IAA as A85-43976 Prepared in cooperation with JPL, Pasadena, Calif.
(NASA-TM-87059; E-2628; NAS 1.15:87059) Avail: NTIS HC A03/MF A01 CSCL 21H

Conceptual designs for O2/H2 chemical and resistojet propulsion systems for the space station was developed and evaluated. The evolution of propulsion requirements was considered as the space station configuration and its utilization as a space transportation node change over the first decade of operation. The characteristics of candidate O2/H2 auxiliary propulsion systems are determined, and opportunities for integration with the OTV tank farm and the space station life support, power and thermal control subsystems are investigated. OTV tank farm boiloff can provide a major portion of the growth station impulse requirements and CO2 from the life support system can be a significant propellant resource, provided it is not denied by closure of that subsystem. Waste heat from the thermal control system is sufficient for many propellant conditioning requirements. It is concluded that the optimum level of subsystem integration must be based on higher level space station studies. Author

N85-35225*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
STATUS OF ADVANCED ORBITAL TRANSFER PROPULSION
L. P. COOPER 1985 26 p refs Proposed for presentation at the 36th Intern. Astronautics Federation Congr., Stockholm, 7-12 Oct. 1985
(NASA-TM-87069; E-2638; NAS 1.15:87069; IAF-85-164) Avail: NTIS HC A03/MF A01 CSCL 21H

A new Orbital Transfer Vehicle (OTV) propulsion system that will be used in conjunction with the Space Shuttle, Space Station and Orbit Maneuvering Vehicle is discussed. The OTV will transfer

men, large space structures and conventional payloads between low Earth and higher energy orbits. Space probes carried by the OTV will continue the exploration of the solar system. When lunar bases are established, the OTV will be their transportation link to Earth. Critical engine design considerations based upon the need for low cost payload delivery, space basing, reusability, aeroassist maneuvering, low g transfers of large space structures and man rating are described. The importance of each of these to propulsion design is addressed. Specific propulsion requirements discussed are: (1) high performance H2/O2 engine; (2) multiple engine configurations totalling no more than 15,000 lbf thrust 15 to 20 hr life; (3) space maintainable modular design; (4) health monitoring capability; and (5) safety and mission success with backup auxiliary propulsion. E.A.K.

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MECHANISMS, AUTOMATION, AND ARTIFICIAL INTELLIGENCE

Includes descriptions of simulations, models, analytical techniques, and requirements for remote, automated and robotic mechanical systems.

A85-33434#
CANADARM STRETCHES SHUTTLE REACH
G. M. LINDBERG (National Aeronautical Establishment, Ottawa, Canada) Aerospace America (ISSN 0740-722X), vol. 23, May 1985, p. 70-72, 74.

The Canadian contribution to the Space Shuttle takes the form of the Remote Manipulator System (RMS) flight hardware and ground support elements. RMS specifications call for the deployment or retrieval of payloads of up to 65,000 lb having a maximum envelope of 15 x 60 ft, with fail-safe design and a 100-mission life. Each of the six joints in the arm is powered by an optically commutated, brushless DC motor which is driven by a servo power amplifier within the arm. The RMS's ability to deploy and retrieve free-flying payloads was demonstrated on STS-7, and satellite repair was conducted on STS-13. O.C.

A85-35959
A STUDY OF GEARS FUNCTIONING IN HIGH VACUUM FOR SPACE ROBOTICS APPLICATIONS [ETUDE D'ENGRENAGES FONCTIONNANT DANS L'ULTRA-VIDE POUR UNE APPLICATION SPATIALE DANS LE DOMAINE DE LA ROBOTIQUE]
L. PETITJEAN (Centre National d'Etudes Spatiales, Toulouse, France) and M. FAURE (Centre d'Etudes Techniques des Industries Mecaniques, Senlis, Oise, France) Revue Francaise de Mecanique (ISSN 0373-6601), no. 1, 1985, p. 43-49. In French.

Robot arms are a necessary appurtenance for space operations such as grappling and holding satellites from another spacecraft or from a Space Station. The operation of the arm is constrained by the target mobility relative to the target and the arm support, mass considerations and reaction forces. The gear configuration at the shoulder of a manipulator arm is a function of the articulation and the reduction ratio. The shoulder is of interest because it receives the highest dynamic and static loading levels. Specifications for an arm, as defined by the French CNES, include a 500 hr vacuum lifetime, maximum speed of 0.05 rd/sec, stiffness of 7 kNm/rd, a motor strength of 8.5 Nm, and a coupling grip of 60 Nm. Braking is achieved electromagnetically. A train of fixed parallel axles has been selected for the transmission for reasons of simplicity, 3-stage reduction, ease of lubrication, efficiency, and low play tolerance. Dry lubricants are needed to eliminate pollution risks. Designs for a test series to examine the performance of the gears in air and vacuum are discussed. M.S.K.

A85-35980*# Vigyan Research Associates, Inc., Hampton, Va.
DECOMPOSITION AND STATE VARIABLE FEEDBACK CONTROL OF ELASTIC ROBOTIC SYSTEMS
S. N. SINGH (Vigyan Research Associates, Inc., Hampton, VA) and A. A. SCHY (NASA, Langley Research Center, Spacecraft Control Branch, Hampton, VA) Institute of Electrical and Electronics Engineers and American Automatic Control Council, American Control Conference, Boston, MA, June 19-21, 1985, Paper. 7 p. refs

Energy-efficient, lightweight robot arms for space applications have considerable structural flexibility. An approach to control of a class of flexible robotic systems is presented. A control law is derived which decouples the joint-angle motion from the flexible motion and, in addition, asymptotically decomposes the elastic dynamics into two subsystems. This allows the design of an elastic mode stabilizer independently based on lower order models representing structural flexibility. The closed-loop system is shown to be globally asymptotically stable and robust to uncertaintly in system parameters. Simulation results show that the combination of nonlinear decoupling and elastic stabilization permits rapid, accurate tracking of large joint angle commands with well damped elastic response, in spite of space vehicle motion and payload uncertainty. Author

A85-38270*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
SPACE STATION AUTOMATED SYSTEMS TESTING/VERIFICATION AND THE GALILEO ORBITER FAULT PROTECTION DESIGN/VERIFICATION
M. R. LANDANO and R. W. EASTER (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, CA) IN: Aerospace Testing Seminar, 8th, Los Angeles, CA, March 21-23, 1984, Proceedings . Mount Prospect, IL, Institute of Environmental Sciences, 1984, p. 227-237. NASA-supported research.

Aspects of Space Station automated systems testing and verification are discussed, taking into account several program requirements. It is found that these requirements lead to a number of issues of uncertainties which require study and resolution during the Space Station definition phase. Most, if not all, of the considered uncertainties have implications for the overall testing and verification strategy adopted by the Space Station Program. A description is given of the Galileo Orbiter fault protection design/verification approach. Attention is given to a mission description, an Orbiter description, the design approach and process, the fault protection design verification approach/process, and problems of 'stress' testing. G.R.

A85-40916
NASA SPACE STATION EFFORT DRIVES EXPERT SYSTEMS RESEARCH AT JOHNSON
A. K. MARSH Aviation Week and Space Technology (ISSN 0005-2175), vol. 122, April 22, 1985, p. 59, 61, 63.

Intensive research efforts prompted by the need to develop operational artificial intelligence systems for the planned NASA space station have had near-term consequences for 'expert systems' directly applicable to current space activities. These 'advisory' systems are to be used in navigation, spacecraft control, failure diagnosis, and mission planning. Attention is presently given to the Navigation Expert System, which will perform at a level comparable to that of three console-operating crew members at Space Shuttle tasks, and such novel concepts as the 'System to Build Systems', which is a software package will be concerned with automated expert system design. O.C.

A85-41372
SPACE-RATED MECHANISMS [LES MECANISMES SPACIAUX]
J. JOUAN (Matra, S.A., Department Instrumentation d'Observation de la Terre, Toulouse, France) L'Aeronautique et L'Astronautique (ISSN 0001-9275), no. 111, 1985, p. 28-34. In French.

Devices operating in space experience vacuum, thermal extremes, and microgravity conditions, and must function with a far greater reliability than more accessible earth-based equipment. Design choices are thereby constrained by the necessity of

extensive ground testing, relatively large margins of safety, the technologies available, and electromechanical considerations. Rotating parts, in a spacecraft, move slowly, but heightened reliability requirements specify an absence of friction. Copolymers and acrylonitrile reserviors are included as lubricant supplies for coating the moving parts. Molybdenum bisulfide and lead films are under development as dry lubricants to avoid both pollution dangers and very fine tolerance characteristics of liquid lubricant systems. Most vital satellite components are redundant (or at least have redundant electronic controls) because of the present absence of on-orbit repairs. Another critical focus is sufficient testing to identify and eliminate any chance of resonant frequencies among the parts of the spacecraft. Examples are cited of several devices devised purely for space applications. M.S.K.

A85-42695#
ARTIFICIAL INTELLIGENCE - A SPACE TOOL OF THE FUTURE?
C. GARRIDO, U. KJAERGAARD MORTENSEN, and T. MONDOT (ESA, Mathematical Support Div., Noordwijk, Netherlands) ESA Bulletin (ISSN 0376-4265), no. 42, May 1985, p. 51-53.

Although AI research has been performed extensively for 15 yr, no clear definition has emerged. A scenario common to most efforts is computer hardware which processes data from sensor inputs, compares the data to a well-defined data (knowledge) base, and arrives at applicable conclusions. The data can also be applied to verifying or discarding a hypothesis. The ESTEC mathematical division has performed a literature review and built a prototype AI system, with emphasis being laid on technologies with near-term space applications. Lisp and Prolog have been selected for the developmental efforts. Prototype attitude and orbit control measurement and data-handling subsystems are being prepared for interaction with Giotto spacecraft ground control simulation to serve as a learning tool and to provide data for guiding the definition of operational systems. M.S.K.

A85-43568
MECHANICAL DEVICES FOR SPACE APPLICATIONS [LES MECANISMES SPATIAUX]
J. JOUAN (Matra, S. A., Departement Instrumentation d'Observation de la Terre, Toulouse, France) Revue Francaise de Mecanique (ISSN 0373-6601), no. 2, 1985, p. 109-115. In French.

The basic principles of mechanical design for moving elements of spacecraft and payload components are reviewed, and sample applications are described and illustrated with drawings and photographs. Topics examined include the effects of vacuum and microgravity, the reliability requirements imposed by the impossibility of on-orbit maintenance, dynamic interfaces with spacecraft systems (possible destabilization or excitation of resonances), and typical applications (deployment and control of solar panels and antennas, orientation of inertial wheels, positioning of payload instruments, operation of life-science apparatus, rendezvous activities, step-motor actuators, and wheels). The need to provide a large torque margin, avoid sliding friction, and keep designs simple and accessible to analysis (i.e., isostatic) is indicated. T.K.

A85-44765
STUDIES ON A LIGHT WEIGHT AND FLEXIBLE ROBOT MANIPULATOR
A. HEMAMI (Montreal, Universite, Canada) Robotics (ISSN 0167-8493), vol. 1, May 1985, p. 27-36. refs

A novel idea for design of a light weight flexible manipulator is studied. A flexible snake-like arm which can take ideally any shape in the three dimensions will necessarily consist of many elements which can move with respect to each other. In order to control the shape of such a device, each element needs an actuator and a sensor. The weight, therefore, becomes a problem of primary importance. This design is based on the manipulation of each element by controlling the lengths of three strings attached to each unit, and kept in tension, from a central drive unit. Each element is of light weight and the weight of the control devices is also taken out from the manipulator arm. The paper discusses the applicability of this design. Author

A85-45398* National Aeronautics and Space Administration, Washington, D.C.
SPACE STATION AUTOMATION AND AUTONOMY
R. F. CARLISLE (NASA, Washington, DC) IN: IECEC '84: Advanced energy systems - Their role in our future; Proceedings of the Nineteenth Intersociety Energy Conversion Engineering Conference, San Francisco, CA, August 19-24, 1984. Volume 1 . La Grange Park, IL, American Nuclear Society, 1984, p. 364-367.

As the complexity of NASA's planned Space Station design grows, decision-making must be transferred from the crew to an onboard computer system devised for maximum man/machine interactions productivity. The Space Station's electrical power subsystem is presently taken as an exemplary case of design evolution from the manual, through the automated, to the fully autonomous control regimes. O.C.

A85-45903#
AEROSPACE INITIATIVES IN ROBOTICS RESEARCH
B. E. GARDNER, J. S. MCLAUGHLIN, T. E. TUCKER, and R. K. WILLIAMSON (Aerospace Corp., El Segundo, CA) IN: Guidance, Navigation and Control Conference, Snowmass, CO, August 19-21, 1985, Technical Papers . New York, AIAA, 1985, p. 237-245. Research supported by the Aerospace Corp. refs
(AIAA PAPER 85-1880)

This paper summarizes results to date of a robotics research program at The Aerospace Corporation. There is an interest in the development of advanced robotics control concepts for flexible automation in both terrestrial and space applications. As a part of the robotics research activity, an off-line robot programming capability was developed in a computer-aided engineering facility. The direct and inverse kinematics of the robot, spline fit trajectory smoothing, and torque calculations for path validation are an integral part of that capability. A dynamics-control simulation test bed has been developed, and has been used to validate a number of advanced robotics control techniques. Additional areas of interest and research activity involve the use of computer vision in position control, the use of force feedback in hybrid position/force control schemes, and the development of an LQR for a compliant, planar manipulator. The results of these efforts are described. Author

A85-45904#
AN APPROACH FOR CONTROL OF ROBOT MANIPULATORS
H. FLASHNER (Southern California, University, Los Angeles) IN: Guidance, Navigation and Control Conference, Snowmass, CO, August 19-21, 1985, Technical Papers . New York, AIAA, 1985, p. 246-252. refs
(AIAA PAPER 85-1881)

An approach to control system design for robot manipulators based on the passivity theory is presented. The approach allows application of the passivity test to the plant manipulator and the controller individually; thus ensuring global stability of the system when the feedback loop is closed. It is shown that a manipulator can be made into a passive system and, therefore, one needs only to iterate on the low order controller during the design. The method can be extended to control design for flexible robots and for direct sampled-data system design. Author

A85-45905*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
INTEGRATED MULTI-SENSORY CONTROL OF SPACE ROBOT HAND
A. K. BEJCZY, E. P. KAN, and R. R. KILLION (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) IN: Guidance, Navigation and Control Conference, Snowmass, CO, August 19-21, 1985, Technical Papers . New York, AIAA, 1985, p. 253-259. NASA-supported research. refs
(AIAA PAPER 85-1882)

Dexterous manipulation of a robot hand requires the use of multiple sensors integrated into the mechanical hand under distributed microcomputer control. Where space applications such

as construction, assembly, servicing and repair tasks are desired of smart robot arms and robot hands, several critical drives influence the design, engineering and integration of such an electromechanical hand. This paper describes a smart robot hand developed at the Jet Propulsion Laboratory for experimental use and evaluation with the Protoflight Manipulator Arm (PFMA) at the Marshall Space Flight Center (MSFC). Author

A85-45907#
AN OPERATIONAL 1/16TH SIZE MODEL OF THE SPACE SHUTTLE MANIPULATOR
C. CHASE, W. CHASE, M. LOHR, G. K. F. LEE, and T. A. W. DWYER, III (Colorado State University, Fort Collins) IN: Guidance, Navigation and Control Conference, Snowmass, CO, August 19-21, 1985, Technical Papers . New York, AIAA, 1985, p. 269-277. refs
(AIAA PAPER 85-1884)

In this paper, a microprocessor-based controller for a six degree of freedom manipulator arm with revolute joints is discussed. The arm is based on a 1/16th size scale model of the Space Shuttle manipulator. A sequential single joint control philosophy is followed. Classical linear control strategies can thus be implemented on a microcomputer for real-time path planning or path following. Intel 8086 - based systems are used to implement the controllers; an 86/12A 32K RAM board along with 8087 co-processor are also employed to speed up computation. A vision system is incorporated in the control loop for on-line pick and place tasks. Limitations of single joint control and requirements for ulterior nonlinear control are also discussed. Author

A85-45908#
SATELLITE MOUNTED ROBOT MANIPULATORS - NEW KINEMATICS AND REACTION MOMENT COMPENSATION
R. W. LONGMAN, R. E. LINDBERG, and M. F. ZEDD (U.S. Navy, Naval Research Laboratory, Washington, DC) IN: Guidance, Navigation and Control Conference, Snowmass, CO, August 19-21, 1985, Technical Papers . New York, AIAA, 1985, p. 278-290.
(AIAA PAPER 85-1885)

When a robot arm is mounted on a satellite, the commanded arm motions produce motion of the satellite and therefore of the robot base. As a result, the robot joint angles that would normally be commanded to produce a prescribed robot end effector position and orientation will result in missing the target. This paper develops a new kind of robot kinematic equations that adjust the joint angle commands to account for base motion. Methods are also developed to compute the satellite attitude disturbances resulting from robot motion for use in a reaction wheel compensation system, or in feedforward control. Author

N85-22460*# National Aeronautics and Space Administration, Washington, D.C.
ADVANCING AUTOMATION AND ROBOTICS TECHNOLOGY FOR THE SPACE STATION AND FOR THE US ECONOMY. VOLUME 1: EXECUTIVE OVERVIEW
Mar. 1985 36 p 2 Vol.
(NASA-TM-87566-VOL-1; NAS 1.15:87566-VOL-1) Avail: NTIS HC A03/MF A01 CSCL 22B

In response to Public Law 98-371, dated July 18, 1984, the NASA Advanced Technology Advisory Committee has studied automation and robotics for use in the Space Station. The Executive Overview, Volume 1 presents the major findings of the study and recommends to NASA principles for advancing automation and robotics technologies for the benefit of the Space Station and of the U.S. economy in general. As a result of its study, the Advanced Technology Advisory Committee believes that a key element of technology for the Space Station is extensive use of advanced general-purpose automation and robotics. These systems could provide the United States with important new methods of generating and exploiting space knowledge in commercial enterprises and thereby help preserve U.S. leadership in space. Author

N85-22461*# National Aeronautics and Space Administration, Washington, D.C.
ADVANCING AUTOMATION AND ROBOTICS TECHNOLOGY FOR THE SPACE STATION AND FOR THE US ECONOMY, VOLUME 2
Mar. 1985 160 p refs 2 Vol.
(NASA-TM-87566-VOL-2; NAS 1.15:87566-VOL-2) Avail: NTIS HC A08/MF A01 CSCL 22B

In response to Public Law 98-371, dated July 18, 1984, the NASA Advanced Technology Advisory Committee has studied automation and robotics for use in the Space Station. The Technical Report, Volume 2, provides background information on automation and robotics technologies and their potential and documents: the relevant aspects of Space Station design; representative examples of automation and robotics; applications; the state of the technology and advances needed; and considerations for technology transfer to U.S. industry and for space commercialization. Author

N85-22613# AEG-Telefunken, Wedel (West Germany).
CONCEPT FOR CONTROLLED FOLD BY FOLD DEPLOYMENT AND RETRACTION OF FLEXIBLE, FOLDABLE SOLAR GENERATORS
G. BEHRENS *In* ESA Photovoltaic Generators in Space p 345-348 Nov. 1984
Avail: NTIS HC A20/MF A01

Control mechanisms for deploying and retracting spacecraft solar blankets were designed. A cog wheel mechanism which enables the blanket to be tensioned with its preload at an arbitrary position is incorporated to avoid out-of-plane oscillations during refolding or partial deployment. Author (ESA)

N85-22623# Royal Netherlands Aircraft Factories Fokker, Schiphol-Oost.
THE OLYMPUS SOLAR ARRAY STRUCTURE AND MECHANISMS
R. ZWANENBURG *In* ESA Photovoltaic Generators in Space p 411-419 Nov. 1984 refs
Avail: NTIS HC A20/MF A01

The Olympus (L-SAT) 4 kW begining-of-life, foldout blanket type solar array is described. Design in modular and power levels from 3 to 7 kW are feasible. The main structural support element is a pallet consisting of a sandwich structure with CFRP face sheets and edgemembers. Deployment is assured by an Astromast, with specially designed tiedown and release systems for primary and secondary deployment. A transfer orbit tensioning mechanism and secondary deployment actuator were designed.
Author (ESA)

N85-23859*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
A CONCEPT FOR A MOBILE REMOTE MANIPULATOR SYSTEM
M. M. MIKULUS, JR., H. G. BUSH, R. E. WALLSOM, and J. K. JENSEN *In its* Large Space Antenna Systems Technol., 1984, Pt. 2 p 793-808 Apr. 1985 refs
Avail: NTIS HC A21/MF A01 CSCL 22B

A conceptual design for a Mobile Remote Manipulator System (MRMS) is presented. This concept does not require continuous rails for mobility (only guide pins at truss hardpoints) and is very compact, being only one bay square. The MRMS proposed is highly maneuverable and is able to move in any direction along the orthogonal guide pin array under complete control at all times. The proposed concept would greatly enhance the safety and operational capabilities of astronauts performing EVA functions such as structural assembly, payload transport and attachment, space station maintenance, repair or modification, and future spacecraft construction or servicing. The MRMS drive system conceptual design presented is a reasonably simple mechanical device which can be designed to exhibit high reliability. Developmentally, all components of the proposed MRMS either exist or are considered to be completely state of the art designs requiring minimal development, features which should enhance reliability and minimize costs. Author

N85-27578# Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Engineering.
ARTIFICIAL INTELLIGENCE IN SPACE PLATFORMS M.S. Thesis
M. A. WRIGHT Dec. 1984 139 p
(AD-A152078; AFIT/GSO/OS/84D-9) Avail: NTIS HC A07/MF A01 CSCL 06D

This thesis determined the feasibility of implementing Artificial Intelligence techniques on orbiting spacecraft. The main thrust was to evaluate the current technology of expert systems (computer programs) and determine their value to satellite tasking. The goal for an expert system to be effective was that it must be able to perform spacecraft stationkeeping without ground assistance. Analysis began by outlining the basic functions of the DSCS III and noting deficiencies could be corrected with conventional computer programming, but stationkeeping required AI techniques for proper execution. Expert systems were then examined and studied for applicability to the primary task of orbit maintenance. R1, an expert system designed to perform computer configuration, was found to be a good baseline for comparison and further development. The process of orbit maintenance, as currently done by human experts, was explained and outlined for expert system design. Finally, a cost analysis provided information which supported further development of AI technology for spacecraft implementation. GRA

N85-27936*# California Univ., San Diego. Automation and Robotics Panel.
AUTOMATION AND ROBOTICS FOR THE NATIONAL SPACE PROGRAM
25 Feb. 1985 142 p refs
(Contract NAGW-629)
(NASA-CR-175881; NAS 1.26:175881; CSI/85-01) Avail: NTIS HC A07/MF A01 CSCL 22B

The emphasis on automation and robotics in the augmentation of the human centered systems as it concerns the space station is discussed. How automation and robotics can amplify the capabilities of humans is detailed. A detailed developmental program for the space station is outlined. E.R.

N85-29561*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
MAN-MACHINE TRADEOFF STUDY
A. FEINBERG and W. F. ZIMMERMAN *In* NASA. Ames Research Center Proc. of the Seminar on Space Station Human Productivity 10 p Mar. 1985
Avail: NTIS HC A99/MF E03 CSCL 05H

An automation assessment was conducted to determine which components of the space station should be selected for automation. The exercise took the form of a man-machine tradeoff study. G.L.C.

N85-29993*# Grumman Aerospace Corp., Bethpage, N.Y.
ANALYSIS OF REMOTE OPERATING SYSTEMS FOR SPACE-BASED SERVICING OPERATIONS, VOLUME 1 Executive Summary
1 Mar. 1985 33 p 2 Vol.
(Contract NAS9-17066)
(NASA-CR-171885; NAS 1.26:171885; SA-ROS-RP-111-1) Avail: NTIS HC A03/MF A01 CSCL 22B

A two phase study was conducted to analyze and develop the requirements for remote operating systems as applied to space based operations for the servicing, maintenance, and repair of satellites. Phase one consisted of the development of servicing requirements to establish design criteria for remote operating systems. Phase two defined preferred system concepts and development plans which met the requirements established in phase one. The specific tasks in phase two were to: (1) identify desirable operational and conceptual approaches for selected mission scenarios; (2) examine the potential impact of remote operating systems incorporated into the design of the space station; (3) address remote operating systems design issues, such as mobility, which are effected by the space station configuration; and (4) define the programmatic approaches for technology development, testing, simulation, and flight demonstration. J.W.G.

N85-29994*# Grumman Aerospace Corp., Bethpage, N.Y.
ANALYSIS OF REMOTE OPERATING SYSTEMS FOR SPACE-BASED SERVICING OPERATIONS. VOLUME 2: STUDY RESULTS
1 Mar. 1985 57 p refs 2 Vol.
(Contract NAS9-17066)
(NASA-CR-171886; NAS 1.26:171886; SA-ROS-RP-111-2) Avail: NTIS HC A04/MF A01 CSCL 22B

The developments in automation and robotics have increased the importance of applications for space based servicing using remotely operated systems. A study on three basic remote operating systems (teleoperation, telepresence and robotics) was performed in two phases. In phase one, requirements development, which consisted of one three-month task, a group of ten missions were selected. These included the servicing of user equipment on the station and the servicing of the station itself. In phase two, concepts development, which consisted of three tasks, overall system concepts were developed for the selected missions. These concepts, which include worksite servicing equipment, a carrier system, and payload handling equipment, were evaluated relative to the configurations of the overall worksite. It is found that the robotic/teleoperator concepts are appropriate for relatively simple structured tasks, while the telepresence/teleoperator concepts are applicable for missions that are complex, unstructured tasks. J.W.G.

N85-29999*# TRW Space Technology Labs., Redondo Beach, Calif.
SPACE STATION AUTOMATION STUDY-SATELLITE SERVICING. VOLUME 1: EXECUTIVE SUMMARY Final Report, Jun. - Nov. 1984
30 Nov. 1984 45 p 2 Vol.
(Contract NAS8-35081)
(NASA-CR-171512; NAS 1.26:171512; Z-4.110.1-84-160-VOL-1)
Avail: NTIS HC A03/MF A01 CSCL 22B

A plan for advancing the state of automation and robotics technology as an integral part of the U.S. space station development effort was studied. This study was undertaken: (1) to determine the benefits that will accrue from using automated systems onboard the space station in support of satellite servicing; (2) to define methods for increasing the capacity for, and effectiveness of satellite servicing while reducing demands on crew time and effort and on ground support; (3) to find optimum combinations of men/machine activities in the performance of servicing functions; and (4) project the evolution of automation technology needed to enhance or enable satellite servicing capabilities to match the evolutionary growth of the space station. A secondary intent is to accelerate growth and utilization of robotics in terrestrial applications as a spin-off from the space station program. J.W.G.

N85-30001*# Martin Marietta Aerospace, Denver, Colo.
SPACE STATION AUTOMATION STUDY. VOLUME 2: TECHNICAL REPORT. AUTONOMOUS SYSTEMS AND ASSEMBLY Final Report
Nov. 1984 254 p refs 2 Vol.
(Contract NAS8-35042)
(NASA-CR-171515; NAS 1.26:171515; MCR84-1878) Avail: NTIS HC A12/MF A01 CSCL 22B

The application of automation to space station functions is discussed. A summary is given of the evolutionary functions associated with long range missions and objectives. Mission tasks and requirements are defined. Space station sub-systems, mission models, assembly, and construction are discussed. R.J.F.

N85-30002*# Martin Marietta Aerospace, Denver, Colo.
SPACE STATION AUTOMATION STUDY. VOLUME 1: EXECUTIVE SUMMARY. AUTONOMOUS SYSTEMS AND ASSEMBLY Final Report
Nov. 1984 64 p 2 Vol.
(Contract NAS8-35042)
(NASA-CR-171514; NAS 1.26:171514; MCR84-1878-VOL-1)
Avail: NTIS HC A04/MF A01 CSCL 22B

The space station automation study (SSAS) was to develop informed technical guidance for NASA personnel in the use of autonomy and autonomous systems to implement space station functions. The initial step taken by NASA in organizing the SSAS was to form and convene a panel of recognized expert technologists in automation, space sciences and aerospace engineering to produce a space station automation plan. G.L.C.

N85-31147*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
SPACE STATION MAN-MACHINE AUTOMATION TRADE-OFF ANALYSIS
W. F. ZIMMERMAN, J. BARD, and A. FEINBERG 15 Feb. 1985 131 p refs Sponsored by NASA
(NASA-CR-176046; JPL-PUB-85-13; NAS 1.26:176046) Avail: NTIS HC A07/MF A01 CSCL 22B

The man machine automation tradeoff methodology presented is of four research tasks comprising the autonomous spacecraft system technology (ASST) project. ASST was established to identify and study system level design problems for autonomous spacecraft. Using the Space Station as an example spacecraft system requiring a certain level of autonomous control, a system level, man machine automation tradeoff methodology is presented that: (1) optimizes man machine mixes for different ground and on orbit crew functions subject to cost, safety, weight, power, and reliability constraints, and (2) plots the best incorporation plan for new, emerging technologies by weighing cost, relative availability, reliability, safety, importance to out year missions, and ease of retrofit. A fairly straightforward approach is taken by the methodology to valuing human productivity, it is still sensitive to the important subtleties associated with designing a well integrated, man machine system. These subtleties include considerations such as crew preference to retain certain spacecraft control functions; or valuing human integration/decision capabilities over equivalent hardware/software where appropriate. Author

N85-32134*# SRI International Corp., Menlo Park, Calif. Artificial Intelligence Center.
NASA SPACE STATION AUTOMATION: AI-BASED TECHNOLOGY REVIEW
O. FIRSCHEIN, M. P. GEORGEFF, W. PARK, P. NEUMANN, W. H. KAUTZ, K. N. LEVITT, R. J. ROM, and A. A. POGGIO 1 Apr. 1985 325 p refs Revised
(Contract NAS2-11864; SRI PROJ. 7268)
(NASA-CR-176094; NAS 1.26:176094) Avail: NTIS HC A14/MF A01 CSCL 22B

Research and Development projects in automation for the Space Station are discussed. Artificial Intelligence (AI) based automation technologies are planned to enhance crew safety through reduced need for EVA, increase crew productivity through the reduction of routine operations, increase space station autonomy, and augment space station capability through the use of teleoperation and robotics. AI technology will also be developed for the servicing of satellites at the Space Station, system monitoring and diagnosis, space manufacturing, and the assembly of large space structures. F.M.R.

N85-32135*# SRI International Corp., Menlo Park, Calif. Artificial Intelligence Center.
NASA SPACE STATION AUTOMATION: AI-BASED TECHNOLOGY REVIEW. EXECUTIVE SUMMARY
O. FIRSCHEIN, M. P. GEORGEFF, W. PARK, P. C. CHEESEMAN, J. GOLDBERG, P. NEUMANN, W. H. KAUTZ, K. N. LEVITT, R. J. ROM, and A. A. POGGIO 26 Mar. 1985 68 p Revised
(Contract NAS2-11864; SRI PROJ. 7268)
(NASA-CR-176096; NAS 1.26:176096) Avail: NTIS HC A04/MF A01 CSCL 22B

Research and Development projects in automation technology for the Space Station are described. Artificial Intelligence (AI) based technologies are planned to enhance crew safety through reduced need for EVA, increase crew productivity through the reduction of routine operations, increase space station autonomy, and augment space station capability through the use of teleoperation and robotics. F.M.R.

N85-32136*# Hughes Aircraft Co., Culver City, Calif.
AUTOMATION STUDY FOR SPACE STATION SUBSYSTEMS AND MISSION GROUND SUPPORT Final Report
1985 82 p refs Sponsored by NASA. Johnson Spacecraft Center
(NASA-CR-176097; NAS 1.26:176097) Avail: NTIS HC A05/MF A01 CSCL 22B

An automation concept for the autonomous operation of space station subsystems, i.e., electric power, thermal control, and communications and tracking are discussed. To assure that functions essential for autonomous operations are not neglected, an operations function (systems monitoring and control) is included in the discussion. It is recommended that automated speech recognition and synthesis be considered a basic mode of man/machine interaction for space station command and control, and that the data management system (DMS) and other systems on the space station be designed to accommodate fully automated fault detection, isolation, and recovery within the system monitoring function of the DMS. F.M.R.

N85-33170*# General Electric Co., Philadelphia, Pa. Space Systems Div.
SPACE STATION AUTOMATION STUDY. AUTOMATION REQUIREMENTS DERIVED FROM SPACE MANUFACTURING CONCEPTS. VOLUME 1: EXECUTIVE SUMMARY Final Report
9 Jul. 1984 34 p
(Contract NAS5-25182)
(NASA-CR-176099; NAS 1.26:176099) Avail: NTIS HC A03/MF A01 CSCL 22B

The two manufacturing concepts developed represent innovative, technologically advanced manufacturing schemes. The concepts were selected to facilitate an in depth analysis of manufacturing automation requirements in the form of process mechanization, teleoperation and robotics, and artificial intelligence. While the cost effectiveness of these facilities has not been analyzed as part of this study, both appear entirely feasible for the year 2000 timeframe. The growing demand for high quality gallium arsenide microelectronics may warrant the ventures. Author

N85-33171*# General Electric Co., Philadelphia, Pa. Space Systems Div.
SPACE STATION AUTOMATION STUDY. AUTOMATION REQUIREMENTS DERIVED FROM SPACE MANUFACTURING CONCEPTS. VOLUME 2: TECHNICAL REPORT Final Report
27 Nov. 1984 125 p
(Contract NAS5-25182)
(NASA-CR-176100; NAS 1.26:176100) Avail: NTIS HC A10/MF A01 CSCL 22B

The automation technology required for remote operations, including manufacturing applications were assessed. Over one hundred potential space station missions were assessed through an extensive review of proposed space station experiments and manufacturing concepts. Two manufacturing design concepts were

developed: (1) gallium arsenide electroepitaxial crystal production and wafer manufacturing facility; and (2) gallium arsenide VLSI microelectronics chip processing facility. A functional overview of the ultimate design concept incorporating the two manufacturing facilities on space station are provided. The concepts were studied separately. This separation allowed conclusions and results to be determined in independent time frames without dependent cross ties. The conclusions and results are discussed in detail. E.R.

N85-33172*# Boeing Aerospace Co., Seattle, Wash.
SPACE STATION AUTOMATION AND ROBOTICS STUDY. OPERATOR-SYSTEMS INTERFACE Final Report
Nov. 1984 72 p refs Sponsored by NASA. Johnson Spacecraft Center Prepared in cooperation with Boeing Computer Services, Inc., Seattle
(NASA-CR-176095; NAS 1.26:176095; D483-10027-1; DE85-902175) Avail: NTIS HC A04/MF A01 CSCL 22B

This is the final report of a Space Station Automation and Robotics Planning Study, which was a joint project of the Boeing Aerospace Company, Boeing Commercial Airplane Company, and Boeing Computer Services Company. The study is in support of the Advanced Technology Advisory Committee established by NASA in accordance with a mandate by the U.S. Congress. Boeing support complements that provided to the NASA Contractor study team by four aerospace contractors, the Stanford Research Institute (SRI), and the California Space Institute. This study identifies automation and robotics (A&R) technologies that can be advanced by requirements levied by the Space Station Program. The methodology used in the study is to establish functional requirements for the operator system interface (OSI), establish the technologies needed to meet these requirements, and to forecast the availability of these technologies. The OSI would perform path planning, tracking and control, object recognition, fault detection and correction, and plan modifications in connection with extravehicular (EV) robot operations. F.M.R.

N85-33174*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
STATEMENT OF AARON COHEN, DIRECTOR, RESEARCH AND ENGINEERING, JOHNSON SPACE CENTER AND CHAIRMAN, SPACE STATION ADVANCED TECHNOLOGY ADVISORY COMMITTEE, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION, BEFORE THE SUBCOMMITTEE ON SCIENCE, TECHNOLOGY, AND SPACE, COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION, UNITED STATES SENATE
A. COHEN 8 Mar. 1985 14 p
(NASA-TM-87497; NAS 1.15:87497) Avail: NTIS HC A02/MF A01 CSCL 22B

The activities of NASA's Space Station Advanced Technology Advisory Committee is discussed. Advanced Technology Advisory Committee (ATAC) activities over the last year are reviewed in preparation of the report to Congress on the potential for advancing automation and robotics technology for the space station and for the U.S. economy. Author

N85-33175*# Martin Marietta Aerospace, Denver, Colo.
SPACE STATION AUTOMATION STUDY: AUTONOMOUS SYSTEMS AND ASSEMBLY, VOLUME 2 Final Report
K. Z. BRADFORD Nov. 1984 254 p refs 2 Vol.
(Contract NAS8-35042)
(NASA-CR-176092; NAS 1.26:176092) Avail: NTIS HC A12/MF A01 CSCL 22B

This final report, prepared by Martin Marietta Denver Aerospace, provides the technical results of their input to the Space Station Automation Study, the purpose of which is to develop informed technical guidance in the use of autonomous systems to implement space station functions, many of which can be programmed in advance and are well suited for automated systems. F.M.R.

N85-33176*# Stanford Univ., Calif.
SPACE ROBOT SIMULATOR VEHICLE Final Report, Mar. 1984 - Mar. 1985
R. H. CANNON, JR. and H. ALEXANDER May 1985 20 p refs Prepared in cooperation with JPL, Pasadena, Calif. Original contains color illustrations
(Contract NAS7-100)
(NASA-CR-176133; JPL-9950-1162; NAS 1.26:176133) Avail: NTIS HC A02/MF A01 CSCL 22B

A Space Robot Simulator Vehicle (SRSV) was constructed to model a free-flying robot capable of doing construction, manipulation and repair work in space. The SRSV is intended as a test bed for development of dynamic and static control methods for space robots. The vehicle is built around a two-foot-diameter air-cushion vehicle that carries batteries, power supplies, gas tanks, computer, reaction jets and radio equipment. It is fitted with one or two two-link manipulators, which may be of many possible designs, including flexible-link versions. Both the vehicle body and its first arm are nearly complete. Inverse dynamic control of the robot's manipulator has been successfully simulated using equations generated by the dynamic simulation package SDEXACT. In this mode, the position of the manipulator tip is controlled not by fixing the vehicle base through thruster operation, but by controlling the manipulator joint torques to achieve the desired tip motion, while allowing for the free motion of the vehicle base. One of the primary goals is to minimize use of the thrusters in favor of intelligent control of the manipulator. Ways to reduce the computational burden of control are described. E.A.K.

N85-33516*# Dornier-Werke G.m.b.H., Friedrichshafen (West Germany).
A MODULAR DOCKING MECHANISM FOR IN-ORBIT ASSEMBLY AND SPACECRAFT SERVICING
F. GAMPE, K. PRIESETT, and R. H. BENTALL (ESA. ESTEC, Noordwijk, Netherlands) *In* NASA. Ames Research Center 19th Aerospace Mech. Symp. p 59-74 Aug. 1985
Avail: NTIS HC A17/MF A01 CSCL 20K

A Docking Mechanism concept is described which is suitable for use with autonomous docking systems. The central feature of using simple cylindrical handles on one side and a type of prism seating on the other is offered as a practical method of achieving a standardized structural interface without freezing continued development of the latches, either technically or commercially. The main emphasis in docking mechanism concepts is in two directions: (1) a very simple docking mechanism, involving mainly the latch mechanism to achieve a structural link; and (2) a sophisticated Docking Mechanism, where the latch mechanism is designed for nonrigid spacecraft and the achievement of very low dynamic interactions between spacecraft during the docking process. Author

N85-33519*# Spar Aerospace Ltd., Toronto (Ontario).
THE DESIGN AND DEVELOPMENT OF A CONSTANT-SPEED SOLAR ARRAY DRIVE
H. M. JONES and N. ROGER *In* NASA. Ames Research Center 19th Aerospace Mech. Symp. p 103-118 Aug. 1985 Sponsored by Canadian Dept. of Communications and International Telecommunications Satellite Organization
Avail: NTIS HC A17/MF A01 CSCL 20K

The design and development of a constant-speed solar array drive system for use in high power communications satellites is described. The relationship between continuity of motion in the solar array drive and spacecraft attitude disturbance is investigated. The selection of the system design based on the design requirements including spacecraft disturbance is discussed. The system comprises two main parts: the drive mechanism including small angle stepper motor and reduction gearing and the control electronics including ministepping drive circuits, such that a very small output step size is achieved. Factors contributing to discontinuities in motion are identified and discussed. Test methods for measurement of very small amplitudes of discontinuity at low rotational rates are described to assist in the testing of similar mechanisms. Author

N85-33522*# Martin Marietta Aerospace, Denver, Colo.
THE DESIGN AND DEVELOPMENT OF A SPACECRAFT APPENDAGE TIE DOWN MECHANISM
W. D. NYGREN and R. HEAD *In* NASA. Ames Research Center 19th Aerospace Mech. Symp. p 167-177 Aug. 1985
Avail: NTIS HC A17/MF A01 CSCL 20K

The design and evolution is described of a spacecraft Appendage Tie Down Mechanism (ATDM). Particular emphasis is paid to the mechanical aspects of using dry lubricants to increase the efficiency of acme threads and worm gearing. The ATDM consists of five major components. These are a dc torque motor, a worm gear speed reducer, the tension bolt (or T-bolt), nut capture and centering jaws and the capture nut. In addition, there are several minor components such as limit switch assemblies and an antibackdrive mechanism which couples the drive motor to the worm shaft. A development model of the ATDM in various configurations was under test for some time. In its latest version, it has successfully completed thermal vacuum testing, vibration testing, and extended life testing. Author

N85-33523*# British Aerospace Public Ltd. Co., Stevenage (England).
THE USE OF PERFLUOROETHER LUBRICANTS IN UNPROTECTED SPACE ENVIRONMENTS
B. H. BAXTER and B. P. HALL *In* NASA. Ames Research Center 19th Aerospace Mech. Symp. p 179-207 Aug. 1985
Avail: NTIS HC A17/MF A01 CSCL 11H

A series of ball bearing tests in simulated space environment are described which determine durability of perfluoroether lubricants. The results of the examination of the test bearings for each stage are described and experimental techniques designed to overcome lubricant degradation are outlined. Author

N85-33525*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
TELEPRESENCE WORK SYSTEM CONCEPTS
L. M. JENKINS *In* NASA. Ames Research Center 19th Aerospace Mech. Symp. p 225-233 Aug. 1985 refs
Avail: NTIS HC A17/MF A01 CSCL 13M

Telepresence has been used in the context of the ultimate in remote manipulation where the operator is provided with the sensory feedback and control to perform highly dexterous tasks. The concept of a Telepresence Work Station (TWS) for operation in space is described. System requirements, concepts, and a development approach are discussed. The TWS has the potential for application on the Space Shuttle, on the Orbit Maneuver Vehicle, on an Orbit Transfer Vehicle, and on the Space Station. The TWS function is to perform satellite servicing tasks and construction and assembly operations in the buildup of large spacecraft. The basic concept is a pair of dexterous arms controlled from a remote station by an operation with feedback. It may be evolved through levels of supervisory control to a smart adaptive robotic system. Author

N85-33526*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
DUAL ARM MASTER CONTROLLER DEVELOPMENT
D. P. KUBAN (ORNL, Tenn.) and G. S. PERKINS *In* NASA. Ames Research Center 19th Aerospace Mech. Symp. p 235-250 Aug. 1985 refs
(Contract DE-AC05-84OR-21400)
Avail: NTIS HC A17/MF A01 CSCL 13M

The advanced servomanipulator (ASM) slave was designed with an anthropomorphic stance gear/torque tube power drives, and modular construction. These features resulted in increased inertia, friction, and backlash relative to tape driven manipulators. Studies were performed which addressed to human factor design and performance tradeoffs associated with the corresponding master controller best suited for the ASM. The results of these studies, as well as the conceptual design of the dual arm master controller, are presented. Author

N85-33532*# Dornier-Werke G.m.b.H., Friedrichshafen (West Germany).
FEATURES OF THE SOLAR ARRAY DRIVE MECHANISM FOR THE SPACE TELESCOPE
R. G. HOSTENKAMP *In* NASA. Ames Research Center 19th Aerospace Mech. Symp. p 315-327 Aug. 1985
Avail: NTIS HC A17/MF A01 CSCL 13M

The solar array drive mechanism for the Space Telescope embodies several features not customarily found on solar array drives. Power and signal transfer is achieved by means of a flexible wire harness for which the chosen solution, consisting of 168 standard wires, is described. The torque performance data of the harness over its temperature range are presented. The off load system which protects the bearings from the launch loads is released by a trigger made from Nitinol, the memory alloy. The benefits of memory alloy and the caveats for the design are briefly discussed. The design of the off load system is described and test experience is reported. Author

N85-33533*# Lockheed Missiles and Space Co., Sunnyvale, Calif.
APPENDANGE DEPLOYMENT MECHANISM FOR THE HUBBLE SPACE TELESCOPE PROGRAM
H. T. GREENFIELD *In* NASA. Ames Research Center 19th Aerospace Mech. Symp. p 329-346 Aug. 1985 refs Sponsored by NASA. Marshall Space Flight Center
Avail: NTIS HC A17/MF A01 CSCL 13M

The key requirements, a design overview, development testing (qualification levels), and two problems and their solutions resolved during the mechanism development testing phase are presented. The mechanism described herein has demonstrated its capability to deploy/restow two large Hubble Space Telescope deployable appendages in a varying but controlled manner. Author

N85-33738*# Science Applications Research, Lanham, Md.
A STRATEGY PLANNER FOR NASA ROBOTICS APPLICATIONS
S. S. BRODD 24 Jul. 1985 52 p refs
(Contract NAS5-28200)
(NASA-CR-175319; NAS 1.26:175319; REPT-85B0504) Avail: NTIS HC A04/MF A01 CSCL 09B

Automatic strategy or task planning is an important element of robotics systems. A strategy planner under development at Goddard Space Flight Center automatically produces robot plans for assembly, disassembly, or repair of NASA spacecraft from computer aided design descriptions of the individual parts of the spacecraft. Author

N85-35210*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
SPACE MISSIONS FOR AUTOMATION AND ROBOTICS TECHNOLOGIES (SMART) PROGRAM
D. L. CLIFFONE and H. LUM, JR. Aug. 1985 10 p refs
(NASA-TM-86820; NAS 1.15:86820; REPT-85375) Avail: NTIS HC A02/MF A01 CSCL 22A

NASA is currently considering the establishment of a Space Mission for Automation and Robotics Technologies (SMART) Program to define, develop, integrate, test, and operate a spaceborne national research facility for the validation of advanced automation and robotics technologies. Initially, the concept is envisioned to be implemented through a series of shuttle based flight experiments which will utilize telepresence technologies and real time operation concepts. However, eventually the facility will be capable of a more autonomous role and will be supported by either the shuttle or the space station. To ensure incorporation of leading edge technology in the facility, performance capability will periodically and systematically be upgraded by the solicitation of recommendations from a user advisory group. The facility will be managed by NASA, but will be available to all potential investigators. Experiments for each flight will be selected by a peer review group. Detailed definition and design is proposed to take place during FY 86, with the first SMART flight projected for FY 89. Author

N85-35637*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
TRICCS: A PROPOSED TELEOPERATOR/ROBOT INTEGRATED COMMAND AND CONTROL SYSTEM FOR SPACE APPLICATIONS
R. W. WILL Jul. 1985 31 p refs
(NASA-TM-87577; NAS 1.15:87577) Avail: NTIS HC A03/MF A01 CSCL 09B

Robotic systems will play an increasingly important role in space operations. An integrated command and control system based on the requirements of space-related applications and incorporating features necessary for the evolution of advanced goal-directed robotic systems is described. These features include: interaction with a world model or domain knowledge base, sensor feedback, multiple-arm capability and concurrent operations. The system makes maximum use of manual interaction at all levels for debug, monitoring, and operational reliability. It is shown that the robotic command and control system may most advantageously be implemented as packages and tasks in Ada. Author

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MATERIALS

Includes mechanical properties of materials, and descriptions and analyses of different structural materials, films, coatings, bonding materials and descriptions of the effects of natural and induced space environments.

A85-30279#
THE DESIGN OF METAL MATRIX COMPOSITE MATERIALS FOR IMPROVED FLEXIBLE SPACECRAFT PERFORMANCE
G. A. LESIEUTRE (HR Textron, Irvine, CA) IN: Structures, Structural Dynamics, and Materials Conference, 26th, Orlando, FL, April 15-17, 1985, Technical Papers. Part 1 . New York, American Institute of Aeronautics and Astronautics, 1985, p. 454-462. refs
(Contract N0024-83-C-5353)
(AIAA PAPER 85-0726)

Structural flexibility in future spacecraft will be significant because of stringent system performance requirements, severe disturbance environments, and size, in view of basic structural and materials limitations. Designers of these advanced spacecraft will have many technical options available to them in the general areas of materials design, structural configuration design, and control system design. The relative merits of different materials in terms of the requirements they generate for a structural control system are examined using a model of a representative antenna spacecraft. Although the technical challenges of flexible spacecraft are here to stay, spacecraft structures made from metal matrix composites can alleviate the severity of the controls challenge.
Author

A85-30311#
PREDICTED TEMPERATURE FIELD IN A THERMOMECHANICALLY HEATED VISCOPLASTIC SPACE TRUSS STRUCTURE
D. H. ALLEN and W. E. HAISLER (Texas A & M University, College Station, TX) IN: Structures, Structural Dynamics, and Materials Conference, 26th, Orlando, FL, April 15-17, 1985, Technical Papers. Part 1 . New York, American Institute of Aeronautics and Astronautics, 1985, p. 773-779. refs
(Contract F49620-83-C-0067)
(AIAA PAPER 85-0829)

This paper focuses on the effect of thermomechanically induced heating on the response of a single member of a space truss structure which behaves viscoplastically. The governing equations are given for a typical truss member, wherein material inelasticity is reflected in constitutive equations via a set of internal state variables, each characterized by a history dependent growth law. The governing equations are coupled in the sense that temperature and displacement are dependent on each other. This difficulty, together with the fact that the inelastic constitutive equations are nonlinear and numerically stiff, requires that a computationally complex semidiscretized finite element spatial technique be utilized to obtain a solution. This procedure, detailed herein, is utilized to predict the response of a typical metallic space truss member under vibrational or cyclic loading. Particular interest is placed on the temperature rise in such a member due to hysteretic loss during structural vibrations and in the presence of complex thermal boundary conditions representative of space conditions. Example cases are constructed for a typical cylindrical bar of 6061-T6 aluminum both with and without special coatings. Results indicate that significant, possibly even catastrophic, heating can occur due to thermomechanical coupling. Author

A85-30382#
EFFECT OF DEGRADATION OF MATERIAL PROPERTIES ON THE DYNAMIC RESPONSE OF LARGE SPACE STRUCTURES
S. KALYANASUNDARAM, J. D. LUTZ, W. E. HAISLER, and D. H. ALLEN (Texas A & M University, College Station, TX) IN: Structures, Structural Dynamics, and Materials Conference, 26th, Orlando, FL, April 15-17, 1985, Technical Papers. Part 2 . New York, American Institute of Aeronautics and Astronautics, 1985, p. 545-551. refs
(Contract F49620-83-C-0067)
(AIAA PAPER 85-0778)

The effect of degradation of material properties on structural frequencies and mode shapes of Large Space Structures (LSS) is investigated. The difficulty and cost of maintenance of LSS make it a necessity to design these structures to operate with a certain amount of load-induced damage. This damage is commonly observed in fibrous composite media. Sensitivity studies conducted on representative space truss structures indicate that degradation of material properties may have a significant effect on the structural mode shapes and frequencies. For even small amounts of reduction in stiffness (10 percent), frequencies and nodal locations may change significnatly. It is clear that these effects must be taken into consideration when designing control systems for LSSs.
Author

A85-35394#
LONG-TERM, LIGHT-INDUCED CHANGES IN DARK CONDUCTIVITY OF KAPTON
M. S. LEUNG, M. B. TUELING, and P. F. MIZERA (Aerospace Corp., El Segundo, CA) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 22, May-June 1985, p. 361-366. Previously cited in issue 22, p. 3219, Accession no. A84-46121. refs
(Contract F04701-83-C-0084)

A85-35803
1984 ANNUAL BOOK OF ASTM STANDARDS. VOLUME 15.03 - SPACE SIMULATION; AEROSPACE MATERIALS; HIGH MODULUS FIBERS AND COMPOSITES
Philadelphia, PA, American Society for Testing and Materials, 1984, 972 p. No individual items are abstracted in this volume.

Standard test methods and practices, specifications, properties, and terminology regarding high-modulus fibers and their composites, space simulations, applied space technology, and aerospace materials are compiled in handbook form and illustrated with diagrams, graphs, and photographs. The aerospace-materials section includes reports on cleaning and chemical-maintenance materials, flammability, contamination, propellants, sandwich constructions, and transparent enclosures and materials. T.K.

A85-37391* Jet Propulsion Lab., California Inst. of Tech., Pasadena.
COMPOSITE MATERIAL TECHNOLOGY REQUIREMENTS FOR LARGE PRECISION SPACE STRUCTURES
P. M. MCELROY and R. G. HELMS (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, CA) IN: National Technical Conference, 16th, Albuquerque, NM, October 9-11, 1984, Proceedings . Covina, CA, Society for the Advancement of Material and Process Engineering, 1984, p. 269-274. NASA-sponsored research.

The development of dimensionally stable, precision composite structures has been recognized as a high risk technology driver in NASA's continuing large space structures research. Attempts are being made to understand the influences controlling thermal performance in such composites, and specifically in composite sandwich panels. The necessary tools for such composite panels' deployment, the experimental verification of analytical predictions, and the demonstration of technology in small scale hardware, are presently addressed. O.C.

A85-37401
NEW DEVELOPMENTS IN CARBON FIBER REINFORCEMENT
P. E. MCMAHON and G. P. DAUMIT (Celanese Plastics and Specialties Co., Chatham, NJ) IN: National Technical Conference, 16th, Albuquerque, NM, October 9-11, 1984, Proceedings . Covina, CA, Society for the Advancement of Material and Process Engineering, 1984, p. 600-608. refs

An account is given of the development and performance of the state-of-the-art GY-80 ultrahigh modulus carbon fiber, which offers higher stiffness and lower thermal expansion coefficient values than previous fibers of this type. Attention is given to the advantages to be derived from the coating of carbon fibers with sizes or finishes, en route to their conversion into fabrics, prepregs, braids, etc. Future space structure application advantages of the GY-80 fibers are noted. O.C.

A85-37403
EFFECT OF SPACE ENVIRONMENTAL CONDITIONS ON MECHANICAL PROPERTIES OF CFRP
K. SONODA, T. TANI, J. ENOMOTO, and K. MURAYAMA (Mitsubishi Electric Corp., Amagasaki, Hyogo, Japan) IN: National Technical Conference, 16th, Albuquerque, NM, October 9-11, 1984, Proceedings . Covina, CA, Society for the Advancement of Material and Process Engineering, 1984, p. 621-632. Research sponsored by the Ministry of International Trade and Industry. refs

A85-37410
DESIGN AND DEVELOPMENT OF THE HORIZONTAL AXIS MEASUREMENT SYSTEM (HAMS) CRADLE
D. J. MACDONALD (Boeing of Canada, Ltd., Winnipeg, Canada) and D. G. ZIMCIK (Department of Communications, Communications Research Centre, Ottawa, Canada) IN: National Technical Conference, 16th, Albuquerque, NM, October 9-11, 1984, Proceedings . Covina, CA, Society for the Advancement of Material and Process Engineering, 1984, p. 705-720.

The Horizontal Axis Measurement System (HAMS) employs the pendulum principle to measure mass, moments, and products of inertia for large spacecraft structures; the cradle of the pendulum on which the spacecraft is mounted had as its principal design-requirement high stiffness with minimum mass. The HAMS cradle has accordingly been fabricated from graphite fiber-reinforced epoxy sandwich materials, using comparatively inexpensive, pitch-based fibers and an inovative design that minimized tooling requirements. Finite element analysis was extensively used to optimize the structural design of the cradle for stiffness and minimum weight. O.C.

A85-37610#
GEOSYNCHRONOUS ORBIT AND LABORATORY IRRADIATION OF SAS (SILVER-ALUMINA-SILICA) QUARTER-WAVE THERMAL CONTROL SURFACES
D. L. MOSSMAN, W. J. SUTHERLAND, and M. K. BARSH (Aerojet ElectroSystems Co., Azusa, CA) American Institute of Aeronautics and Astronautics, Thermophysics Conference, 20th, Williamsburg, VA, June 19-21, 1985. 4 p. refs
(AIAA PAPER 85-0950)

The present investigation involves the irradiation of four samples, which consisted of three SAS-coated metallic substrates and one reference quartz/silver second-surface mirror. The latter is representative of low absorptance reflectors currently used extensively for thermal control on orbiting spacecraft. The process for depositing SAS (Silver-Alumina-Silica) consists of two steps. The first step involves the deposition of silver to a thickness of 1000 A in vacuum. During the second step, alumina and silica are deposited in vacuum to thicknesses of (22 lambda)/4 and (6 lambda)/4 respectively, where lambda equals 550 nm. All four samples were mounted on separate calorimeters in the radiation facility. The results of the irradiation experiments showed that SAS is a promising candidate for thermal control applications. G.R.

A85-37678#
CORRELATION OF LABORATORY AND FLIGHT DATA FOR THE EFFECTS OF ATOMIC OXYGEN ON POLYMERIC MATERIALS
P. W. KNOPF, R. J. MARTIN, R. E. DAMMANN, and M. MCCARGO (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) American Institute of Aeronautics and Astronautics, Thermophysics Conference, 20th, Williamsburg, VA, June 19-21, 1985. 12 p. refs
(AIAA PAPER 85-1066)

Recent Shuttle flights indicate that many surface protective materials commonly employed in aerospace systems are particularly affected by degradaation due to the atomic oxygen environment of the low earth orbit (LEO). Such materials include Kapton, Mylar, Kevlar, and polyurethane. It appears that surface oxidation can be produced by atoms impinging on a surface with velocities close to 8 km/s. The degradation involves changes in material weight (loss), surface morphology, strength, and thermal/optical properties. An investigation was conducted with the aim to obtain a better understanding of the processes leading to the degradation. Laboratory studies involving a simulation of conditions found in LEO were conducted along with a flight experiment. The obtained results confirm the existence of two mechanisms of degradation in LEO. The mechanisms are related to a fast surface oxidation and a slower, diffusion limited bulk oxidation. G.R.

A85-38262#
COMPARISON OF SHIELDING EFFECTIVENESS BETWEEN A GRAPHITE/EPOXY AND AN ALUMINUM SPACECRAFT STRUCTURE
G. SHUMAKER (USAF, Wright-Patterson AFB, OH) and R. C. SCOTT (Rockwell International Corp., Pittsburgh, PA) IN: Aerospace Testing Seminar, 8th, Los Angeles, CA, March 21-23, 1984, Proceedings . Mount Prospect, IL, Institute of Environmental Sciences, 1984, p. 111-117.

This paper presents a comparison of the EMI/EMC shielding effectiveness between a full-scale graphite/epoxy satellite structure and an aluminum satellite structure. The comparison, made over a frequency range of 14 kHz to 18 GHz, is based on a series of tests that involved electrical bonding resistance, seam leakage at radio frequencies, 'H' field, 'E' field, and plane wave measurements. The test program, which was conducted at Genisco, included six 18-inch test panels representing graphite/epoxy and aluminum spacecraft structure elements, the Advanced Composite Equipment Support Module/Global Positioning System (ACESM/GPS) Block I, and the GPS Block I Development Test Vehicle (DTV). Both the two- and three-antenna test setup techniques were utilized to establish the spacecrafts' shielding effectiveness. The results of the test series show that at least 20 dB of shielding is inherent in

the graphite/epoxy structure, and about 4 dB more in the DTV spacecraft. This inherent attenuation is important and should be planned into the EMC design/protection for future spacecraft programs. Author

A85-49902
COMPOSITE SILICONE RUBBER SEAL FOR THE SPACE TELESCOPE PROGRAM
T. M. TANABE, E. N. YOSHIOKA (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA), and A. ANISMAN SAWE, Annual Conference, 43rd, Atlanta, GA, May 21-23, 1984. 16 p.
(SAWE PAPER 1574)

During the development of NASA's Space Telescope, suitable seal materials were selected and verified for environmental requirements that encompassed the retention of physical, mechanical, and sealing properties at low temperatures of -170 F, protection against electromagnetic interference, the release of negligible amounts of volatile products in space environments, and complete sealing of any stray light from optical and telemetry sections. Two types of composite silicone rubber seal, one carbon-loaded and the other embedded metal mesh, were developed; attention is presently given to the iterative configuration design process and evaluation undertaken for the evolution of these two solutions. O.C.

A85-49903
MATERIAL SELECTION FOR LIGHTWEIGHT, DIMENSIONALLY STABLE SPACE STRUCTURES - AN ELASTIC/PLASTIC ANALYTICAL TRADE STUDY
M. H. KURAL, R. A. MOORE, and W. W. SABLE (Lockheed Missiles and Space Co., Inc., Space Systems Div., Sunnyvale, CA) SAWE, Annual Conference, 43rd, Atlanta, GA, May 21-23, 1984. 10 p. refs
(SAWE PAPER 1577)

The present analytical trade studies of material systems applicable to dimensionally stable deployable space antennas have selected graphite/epoxy as the baseline material for the antenna's ribs in order to meet stiffness and weight requirements; this rib laminate was designed for maximum stiffness and minimum thermal and viscoelastic distortion. Thermal expansion control was provided by the adhesion of various metallic foils on the outer surfaces of the rib. The requirement for foil elasticity, together with such design constraints as thermal conductivity, weight, and ease of fabrication, favor beryllium-copper surface foil as the primary foil candidate. O.C.

N85-22477*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
LABORATORY STUDIES OF KAPTON DEGRADATION IN AN OXYGEN ION BEAM
D. C. FERGUSON *In its* Spacecraft Environ. Interactions Technol., 1983 p 81-90 Mar. 1985 refs
Avail: NTIS HC A99/MF E03 CSCL 18H

Results are presented from a preliminary laboratory investigation of the degradation of the widely used polyimide Kapton under oxygen ion bombardment. Recent space shuttle flights have shown that Kapton and some other materials exposed to the apparent ram flow of residual atmosphere (at orbital velocity in low Earth orbit) lose mass and change their optical properties. It was hypothesized that these changes are caused by chemical interaction with atomic oxygen, aided by the 5-eV impact energy of atmospheric oxygen atoms in the ram. The reaction rate under O(+) bombardment seemed to be independent of incident energy over a wide range of energies. Although the flux of thermal ions in this experiment was much greater than the accelerated flux, the observed Kapton degradation was limited to the beam area and ram flow direction. This is consistent with an activation energy above the thermal energies but well below the beam energies. The results reproduce well the material loss, optical changes, SEM surface structure, and ram directionality of the samples returned by the shuttle. These factors, along with the lack of degradation under argon ion bombardment, are convincing evidence for ram flow oxidation as the mechanism of degradation. B.G.

N85-22481*# Air Force Geophysics Lab., Hanscom AFB, Mass.
CHARGING OF DMSP/F6 SPACECRAFT IN AURORA ON 10 JANUARY 1983
A. L. BESSE, A. G. RUBIN, and D. A. HARDY *In* NASA. Lewis Research Center Spacecraft Environ. Interactions Technol., 1983 p 125-130 Mar. 1985 refs
Avail: NTIS HC A99/MF E03 CSCL 22B

Spacecraft charging has been widely observed in geosynchronous orbit on the ATS-5 and ATS-6 pair and on the SCATHA spacecraft. An adequate theory for explaining the observations exist. Neither the data or theory can be exported to low polar orbit and its drastically different environment. Evidence of charging on the DMSP F6 spacecraft is presented. A simple model is set up explaining the observations. Two independent instruments on the spacecraft showed charging to a moderate (44 volts) negative potential. The selection spectrometer showed a flux of 2 billion electrons per sq. cm. sec. ster. peaked at 9.5 keV. This was marginally sufficient to overcome the flux of cold ambient ions. Charging calculations are presented showing where simplications are justified and where serious uncertainties exist. More serious charging is predicted for the Shuttle in polar orbit. G.L.C.

N85-22483*# Southwest Research Inst., San Antonio, Tex.
POLAR PLASMAS AS OBSERVED BY DYNAMICS EXPLORERS 1 AND 2
J. N. BARFIELD, J. BURCH, C. GURGIOLO, C. LIN, D. WINNINGHAM, and N. A. SAFLEKOS *In* NASA. Lewis Research Center Spacecraft Environ. Interactions Technol., 1983 p 155-176 Mar. 1985 refs
(Contract NAS5-26363; NAS5-25693; F19628-82K-0024; FY7121-83-N-001)
Avail: NTIS HC A99/MF E03 CSCL 20I

Plasma measurements from the Dynamics Explorer 1 and 2 satellites were used to characterize the polar cap environment. Analysis of numerous polar-cap passes indicate that, in general, three major regimes of plasma exist: (1) polar rain--electrons with magnetosheath-like energy spectra but much lower densities, most intense near the cusp and weakening toward the central polar cap; (2) polar wind--low energy upward flowing ions with both field-aligned and conical distributions; and (3) acceleration events--sporadic events consistent with the acceleration of electrons and positive ions by parallel electric fields. (1) to (3) were observed at high altitudes by Dynamics Explorer 1, while (1) and (3) were also observed at low altitudes by Dynamics Explorer 2. The plasma parameters associated with these plasma regimes are presented and discussed in terms of source and acceleration mechanisms. G.L.C.

N85-22511*# Pennsylvania State Univ., University Park.
MASS SPECTRA OF NEUTRAL PARTICLES RELEASED DURING ELECTRICAL BREAKDOWN OF THIN POLYMER FILMS
B. R. F. KENDALL *In* NASA. Lewis Research Center Spacecraft Environ. Interactions Technol., 1983 p 525-535 Mar. 1985 refs
(Contract NSG-3301)
Avail: NTIS HC A99/MF E03 CSCL 11G

A special type of time-of-flight mass spectrometer triggered from the breakdown event was developed to study the composition of the neutral particle flux released during the electrical breakdown of polymer films problem. Charge is fed onto a metal-backed polymer surface by a movable smooth platinum contact. A slowly increasing potential from a high-impedance source is applied to the contact until breakdown occurs. The breakdown characteristics is made similar to those produced by an electron beam charging system operating at similar potentials. The apparatus showed that intense instantaneous fluxes of neutral particles are released from the sites of breakdown events. For Teflon FEP films of 50 and 75 microns thickness the material released consists almost entirely of fluorocarbon fragments, some of them having masses greater than 350 atomic mass units amu, while the material released from a 50 micron Kapton film consists mainly of light hydrocarbons with masses at or below 44 amu, with additional carbon monoxide

and carbon dioxide. The apparatus is modified to allow electron beam charging of the samples. E.A.K.

N85-22512*# Case Western Reserve Univ., Cleveland, Ohio.
ELECTRON YIELDS FROM SPACECRAFT MATERIALS
K. YANG, W. L. GORDON, and R. W. HOFFMAN *In* NASA. Lewis Research Center Spacecraft Environ. Interactions Technol., 1983 p 537-545. Mar. 1985 refs
(Contract NSG-3197)
Avail: NTIS HC A99/MF E03 CSCL 22B

Photoyields and secondary electron emission (SEE) characteristics were determined under UHV conditions for a group of insulating materials used in spacecraft applications. The SEE studies were carried out with a pulsed primary beam while photoyields were obtained with a chopped photon beam from a Kr resonance source with major emission at 123.6 nm. This provides a photon flux close to that of the Lyman alpha in the space environment. Yields per incident photon are obtained relative to those from a freshly evaporated and air oxidized Al surface. Results are presented for Kapton, FEP Teflon, the borosilicate glass covering of a shuttle tile, and spacesuit outer fabric. E.A.K.

N85-22513*# Hughes Research Labs., Malibu, Calif.
KAPTON CHARGING CHARACTERISTICS: EFFECTS OF MATERIAL THICKNESS AND ELECTRON-ENERGY DISTRIBUTION
W. S. WILLIAMSON, C. R. DULGEROFF, J. HYMANN, and R. VISWANATHAN (Hughes Space and Communications Group, Los Angeles) *In* NASA. Lewis Research Center Spacecraft Environ. Interactions Technol., 1983 p 547-558 Mar. 1985 refs
Avail: NTIS HC A99/MF E03 CSCL 11G

Charging characteristics of polyimide (Kapton) of varying thicknesses under irradiation by a very-low-curent-density electron beam, with the back surface of the sample grounded are reported. These charging characteristics are in good agreement with a simple analytical model which predicts that in thin samples at low current density, sample surface potential is limited by conduction leakage through the bulk material. The charging of Kapton in a low-current-density electron beam in which the beam energy was modulated to simulate Maxwellian and biMaxwellian distribution functions is measured. E.A.K.

N85-22514*# SRI International Corp., Menlo Park, Calif.
ELECTRICAL CONDUCTION IN POLYMER DIELECTRICS
D. B. COTTS *In* NASA. Lewis Research Center Spacecraft Environ. Interactions Technol., 1983 p 559-569 Mar. 1985 refs
(Contract F19628-81-C-0076)
Avail: NTIS HC A99/MF E03 CSCL 11G

The use of polymer dielectrics with moderate resistivities could reduce or eliminate problems associated with spacecraft charging. The processes responsible for conduction and the properties of electroactive polymers are reviewed, and correlations drawn between molecular structure and electrical conductivity. These structure-property relationships led to the development of several new electroactive polymer compositions and the identification of several systems that have the requisite thermal, mechanical, environmental and electrical properties for use in spacecraft. E.A.K.

N85-22584# Giessen Univ. (West Germany). Inst. of Physics.
ELECTROSTATIC DISCHARGE TESTING ON A CARBON FIBER SOLAR PANEL STRUCTURE
N. K. NIKOLAIZIG, K. H. GROH, and H. W. LOEB *In* ESA Photovoltaic Generators in Space p 115-122 Nov. 1984 refs
(Contract ESTEC-5413/83/NL-PB)
Avail: NTIS HC A20/MF A01

Electrostatic charging of the ECS solar array structure was studied in a substorm test facility. Though the structure exhibits overall conductivity, irradiation tests show that the surface charges locally up to -1.4 kV. The surface potentials are not hazardous. Arc discharges are not observed. Conductivity of the material is reduced with decreasing sample temperature, resulting in a marked increase of the surface potential. Tests with a floating sample show that the solar array structure including Alcore charges up to high negative potentials corresponding to the energy of the impinging electron beam. Author (ESA)

N85-23831*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
NASA SPACE MATERIALS RESEARCH
D. R. TENNEY, S. S. TOMPKINS, and G. F. SYKES *In its* Large Space Antenna Systems Technol., 1984 p 301-329 Apr. 1985 refs
Avail: NTIS HC A20/MF A01 CSCL 11G

The effect of the space environment on: (1) thermal control coatings and thin polymer films; (2) radiation stability of 250 F and 350 F cured graphite/epoxy composites; and (3) the thermal mechanical stability of graphite/epoxy, graphite/glass composites are considered. Degradation in mechanical properties due to combined radiation and thermal cycling is highlighted. Damage mechanisms are presented and chemistry modifications to improve stability are suggested. The dimensional instabilities in graphite/epoxy composites associated with microcracking during thermal cycling is examined as well as the thermal strain hysteresis found in metal-matrix composites. A.R.H.

N85-25435*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
SPECTROSCOPIC ANALYSIS OF RADIATION-GENERATED CHANGES IN TENSILE PROPERTIES OF A POLYETHERIMIDE FILM
E. R. LONG, JR. and S. A. T. LONG May 1985 38 p refs
(NASA-TP-2429; L-15873; NAS 1.60:2429) Avail: NTIS HC A03/MF A01 CSCL 11D

The effects of electron radiation on Ultem, a polyetherimide were studied for doses from 2 x 10 to the 9th power to 6 x 10 to the 9th power rad. Specimens were studied for tensile property testing and for electron paramagnetic resonance and infrared spectroscopic measurements of molecular structure. A Faraday cup design and a method for remote temperature measurement were developed. The spectroscopic data show that radiation caused dehydrogenation of methyl groups, rupture of main-chain ether linkage, and opening of imide rings, all to form radicals and indicate that the so-formed atomic hydrogen attached to phenyl radicals, but not to phenoxyl radicals, which would have formed hydroxyls. The observed decays of the radiation-generated phenoxyl, gem-dimethyl, and carbonyl radicals were interpreted as a combining of the radicals to form crosslinking. This crosslinking is the probable cause of the major reduction in the elongation of the tensile specimens after irradiation. Subsequent classical solubility tests indicate that the irradiation caused massive crosslinking. A.R.H.

N85-29544*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
MATERIALS AND PROCESSES CONTROL FOR SPACE APPLICATIONS
G. A. BLACKBURN *In its* Proc. of the Seminar on Space Station Human Productivity 10 p Mar. 1985
Avail: NTIS HC A99/MF E03 CSCL 13L

Materials and processes control relative to space applications is discussed. The components of a total material and process control system are identified, contamination control issues are listed, and recommendations are made. R.J.F.

N85-30033*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
HIGH PERFORMANCE MIXED BISIMIDE RESINS AND COMPOSITES BASED THEREON Patent Application
J. A. PARKER, A. H. HEIMBUCH, M. T. S. HSU (HC Chem Research and Service Corp.), and T. S. CHEN, inventors (to NASA) (HC Chem Research and Service Corp.) 4 Apr. 1985 25 p
(NASA-CASE-ARC-11538-1-SB; NAS 1.71:ARC-11538-1-SB; US-PATENT-APPL-SN-719796) Avail: NTIS HC A02/MF A01 CSCL 11D

The invention relates to mixed bismaleimide/biscitraconimide resins. Mixtures of the two resins produces materials which have better handling, processing or mechanical and thermal properties, particularly in graphite composites, than materials made with the individual resins. The mechanical strength of cured graphite composites prepared from a 1:1 copolymer of such bisimide resins is excellent at both ambient and elevated temperatures. The copolymer mixture provides improved composites which are lighter than metals and replace metals in many aerospace applications. NASA

N85-30137*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
ION BEAM SPUTTER-DEPOSITED THIN FILM COATINGS FOR PROTECTION OF SPACECRAFT POLYMERS IN LOW EARTH ORBIT
B. A. BANKS, M. J. MIRTICH, S. K. RUTLEDGE, D. M. SWEC, and H. K. NAHRA (Cleveland State Univ.) 1985 24 p refs Presented at the 23rd Aerospace Sci. Meeting, Reno, Nev., 14-17 Jan. 1985; sponsored by AIAA
(NASA-TM-87051; E-2454; NAS 1.15:87051) Avail: NTIS HC A02/MF A01 CSCL 11B

Ion beam sputter-deposited thin films of Al2O3, SiO2, and a codeposited mixture of predominantly SiO2 with small amounts of a fluoropolymer were evaluated both in laboratory plasma ashing tests and in space on board shuttle flight STS-8 for effectiveness in preventing oxidation of polyimide Kapton. Measurements of mass loss and optical performance of coated and uncoated polyimide samples exposed to the low Earth orbital environment are presented. Optical techniques were used to measure loss rates of protective films exposed to atomic oxygen. Results of the analysis of the space flight exposed samples indicate that thin film metal oxide coatings are very effective in protecting the polyimide. Metal oxide coatings with a small amount of fluoropolymer codeposited have the additional benefit of great flexibility. Author

N85-31366# Construcciones Aeronauticas S.A., Madrid (Spain). Space Div.
HIGH REFLECTIVE SURFACES FOR MILLIMETER RF WAVES, PHASE A Final Report
Paris ESA 22 Oct. 1984 396 p refs
(Contract ESA-5263/82/NL-GM)
(HRS-FR-01; ESA-CR(P)-2006) Avail: NTIS HC A17/MF A01

The identification, application, and testing of processes and techniques for metallizing CFRP antenna reflectors for a spaceborne 100 to 300 GHz radiometer, 2 m diameter, are described. Final selection must be between electrolytic and sputtered applications, after analyzing metallization compatibility with the antenna fabrication process. Reflecting surface environmental response must be improved. Metallic layer properties must be correlated with the metallization process parameters. For the electrical test set-up, accuracy range of 0.002 dB is difficult to reduce up to 0.001 dB required. Development effort involved suggests the convenience of reviewing accuracy requirements after analyzing impact of the quoted value over radiometer system performances. Demonstration of the measurement technique over flat samples at 142 GHz reveals the possible existence of error sources previously unaccounted for. Author (ESA)

N85-33144# Joint Publications Research Service, Arlington, Va.
EFFECTS OF ENVIRONMENT ON SPACECRAFT MATERIALS
In its USSR Rept.: Space (JPRS-USP-84-006) p 113-115 14 Nov. 1984 Transl. into ENGLISH from the book "Vozdeystviye Okruzhayushchey Sredy na Materialy Kosmicheskikh Apparatov (Novoye v Zhizni, Nauke, Tekhnike: Seriya Kosmonavtika, Astronomiya)" Moscow, Znaniye, no. 4, Apr. 1983 p 2-6
Avail: NTIS HC A08

The processes of space environment effects on the materials of satellites, orbital and interplanetary stations determine characteristics such as operating time, reliability, work and defense functions during manned flights. Current concepts in these processes are described. The study of which will determine further progress of space exploration. E.A.K.

N85-33168*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
A SURVEY OF STRUCTURAL MATERIAL ISSUES FOR A SPACE STATION
J. A. HAGAMAN Washington Aug. 1985 24 p refs
(NASA-TM-86385; L-15806; NAS 1.15:86385) Avail: NTIS HC A02/MF A01 CSCL 22B

An NASA enters the definition phase of the space station project, one of the important issues to be considered is structural material selection. The complexity of the space station and its long life requirement are two key factors which must be considered in the material selection process. Both aluminum and graphite/epoxy are considered as potential structural materials. Advantages and disadvantages of these materials with respect to mechanical and thermal considerations, space environment, manufacturing, and cost are discussed. R.J.F.

12

INFORMATION AND DATA MANAGEMENT

Includes descriptions, requirements, and trade studies of different information and data system hardware and software, languages, architecture, processing and storage requirements for managing and monitoring of different systems and subsystems.

A85-37166
THE SPACE STATION DATA SYSTEM AND THE USER
L. H. KASULKA (McDonnell Douglas Astronautics Co., Huntington Beach, CA) IN: New opportunities in space; Proceedings of the Twenty-first Space Congress, Cocoa Beach, FL, April 24-26, 1984 . Cape Canaveral, FL, Canaveral Council of Technical Societies, 1984, p. 5-46 to 5-62. refs

Aspects of the Space Station Data System (SSDS) are discussed. Trends in data acquisition and cost as they reflect the demand on the SSDS from the user community are summarized, and the key data characteristics of the MDAC mission set are described. The functional requirements of a Space Station end-to-end data system are discussed, and some preliminary concepts and considerations for the system architecture and for user support are presented. A simplified model of this system is shown, and some key technology needs for it that will meet user needs at affordable costs are listed. C.D.

A85-42556
COMMUNICATIONS FOR THE SPACE STATION
J. L. MCLUCAS (Comsat, World Systems Div., Washington, DC) IN: From Spacelab to Space Station; Proceedings of the Fifth Symposium, Hamburg, West Germany, October 3-5, 1984 . San Diego, CA, Univelt, Inc., 1985, p. 111-119.
(AAS PAPER 84-309)

The application of currently available space communications technology to meet the needs of the planned Space Station is discussed and illustrated with diagrams and drawings. It is predicted that the Station will have data-rate and communications

requirements similar to those met by present communications satellites, that it will not operate as a communications satellite itself, that communications with manned or unmanned coorbiting spacecraft will be mainly via optical links, and that communication with the ground will be via a second-generation version of TDRS, possibly using an additional earth station located in Europe. T.K.

A85-42592*
PROTECTING INTELLECTUAL PROPERTY IN SPACE; PROCEEDINGS OF THE AEROSPACE COMPUTER SECURITY CONFERENCE, MCLEAN, VA, MARCH 20, 1985
Conference sponsored by NASA, AIAA, and Mitre Corp. New York, IEEE, 1985, 98 p. For individual items see A85-42593 to A85-42600.

The primary purpose of the Aerospace Computer Security Conference was to bring together people and organizations which have a common interest in protecting intellectual property generated in space. Operational concerns are discussed, taking into account security implications of the space station information system, Space Shuttle security policies and programs, potential uses of probabilistic risk assessment techniques for space station development, key considerations in contingency planning for secure space flight ground control centers, a systematic method for evaluating security requirements compliance, and security engineering of secure ground stations. Subjects related to security technologies are also explored, giving attention to processing requirements of secure C3/I and battle management systems and the development of the Gemini trusted multiple microcomputer base, the Restricted Access Processor system as a security guard designed to protect classified information, and observations on local area network security. G.R.

A85-42593
SECURITY IMPLICATIONS OF THE SPACE STATION INFORMATION SYSTEM
R. W. BURNS (ORI, Inc., Rockville, MD) IN: Protecting intellectual property in space; Proceedings of the Aerospace Computer Security Conference, McLean, VA, March 20, 1985 . New York, IEEE, 1985, p. 3-10. refs

The present paper concentrates on aspects of the Space Station itself, all Space Station Program Elements (SSPE) that interact with the Space Station, and the telecommunications of the Space Station to the ground system through NASA's Tracking and Data Relay Satellite System (TDRSS). It is pointed out that one of the major concerns of potential commercial customers of the Space Station is NASA's ability to assure data privacy. A Space Station Information System (SSIS) overview is provided, and the types of user data are examined. Security implications are discussed, taking into account the SSIS environment, the protection of the physical assets of the SSIS, personnel security, computer hardware, computer software, procedural (operational) security, communications security, emanation security, and education and training regarding the security implications of the SSIS. G.R.

N85-24769 Centre National d'Etudes Spatiales, Toulouse (France).
SPACEBORNE AUTOMATIC DATA PROCESSING [AUTOMATIQUE SPATIALE]
M. MAURETTE *In its* Space Math. for the Prepn. and the Develop. of Satellite Exploit. p 613-619 1984 refs In FRENCH
Avail: CEPADUES, Toulouse, France

Real time onboard data processing by satellite-borne computers is discussed. Orbital control and guidance are considered. Attitude control of rigid, spinning, three-axis stabilized, and flexible satellites is described. Robotics and the development of spaceborne automation are mentioned. Author (ESA)

N85-32828# Informatique Internatinale S.A., Rungis (France).
COMPARATIVE STUDY ON DATA SYSTEM ARCHITECTURES Final Report
P. VIELCANET, H. HORGEN, T. DEMOY (GIXI), and P. HOWLETT (Societe Francaise d'Equipmements pour la Navigation Aerienne) Paris ESA Nov. 1984 325 p refs
(Contract ESTEC-5524/83/NL-PP)
(ESA-CR(P)-2015) Avail: NTIS HC A14/MF A01

Space application of microprocessor based distributed processing systems set up for ground or airborne utilization was assessed for a manned space station and a large unmanned platform. The survey suggests that the transposition of ground based or airborne solutions to space applications is a technological challenge mainly with respect to space radiation hardening. However, promising trends towards compactness, performance, and reliability are noted. The selection of a qualification method for VLSI components is undecided. Commonality between space and ground computer systems seems achievable in the medium term for manned missions. Spacecraft performance, operational flexibility, and user convenience can be enhanced, at affordable cost, through increased spacecraft automation and autonomy. Many instances of autonomy, intelligence, and stringent requirements can be found in current ground process control applications. Critical reliability and availability requirements are met by specific airborne distributed computer systems implementations. Author (ESA)

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ACCOMMODATIONS

Includes descriptions of simulations, analyses, trade studies, and requirements for safe efficient procedures, facilities, and support equipment on the ground and in space for processing, servicing, verification and checkout of cargo and equipment.

N85-23863*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
SPACE TECHNOLOGY EXPERIMENTS PLATFORM (STEP) STATUS: AN IN-SPACE TEST FACILITY
J. E. HARRIS *In its* Large Space Antenna Systems Technol., 1984, Pt. 2 p 877-891 Apr. 1985
Avail: NTIS HC A21/MF A01 CSCL 22B

Designed for utilization of the space transportation system for technology experiments in space, the space technology experiment platform (STEP) is a shuttle-borne experiment support facility for use primarily for structures, structural dynamics, and control flexible structures technology flight experiments. The STEP concept is discussed as well as shows its relationship to broad NASA goals and objectives. The development chronology is presented and the current system capability in block diagram format is described. The STEP development schedule is included. E.R.

N85-26853*# University of Central Florida, Orlando. Dept. of Computer Engineering.
A SLAM II SIMULATION MODEL FOR ANALYZING SPACE STATION MISSION PROCESSING REQUIREMENTS Final Report
D. G. LINTON 11 May 1985 112 p
(Contract NAG10-13)
(NASA-CR-175664; NAS 1.26:175664) Avail: NTIS HC A06/MF A01 CSCL 22B

Space station mission processing is modeled via the SLAM 2 simulation language on an IBM 4381 mainframe and an IBM PC microcomputer with 620K RAM, two double-sided disk drives and an 8087 coprocessor chip. Using a time phased mission (payload) schedule and parameters associated with the mission, orbiter (space shuttle) and ground facility databases, estimates for ground facility utilization are computed. Simulation output associated with the science and applications database is used to assess alternative mission schedules. Author

N85-29573*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
THE ROLE OF MOCK-UPS IN THE DEVELOPMENT OF ORBITAL REPLACEABLE UNITS (ORU)
G. A. JOHNSON *In its* Proc. of the Seminar on Space Station Human Productivity 26 p Mar. 1985
Avail: NTIS HC A99/MF E03 CSCL 05H

Orbital Replaceable Units (ORU) is defined as any unit designed for replacement while in orbit. Two types are given. The number of ORU and the ratio of types is given as a function of the particular spacecraft. The purpose of the study is to develop and validate hardware design and operations for on orbit replacement of large modular ORU's. Two types of of testing are outlined; 1-G tests and neutral buoyancy tests. E.R.

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GROWTH

Includes descriptions of scenarios, analyses and system technology requirements for the evolutionary growth of the Space Station system.

A85-37170* McDonnell-Douglas Astronautics Co., Huntington Beach, Calif.
AN EVOLUTIONARY GEO TRANSPORTATION SYSTEM
G. MARKUS (McDonnell Douglas Astronautics Co., Huntington Beach, CA) IN: New opportunities in space; Proceedings of the Twenty-first Space Congress, Cocoa Beach, FL, April 24-26, 1984 . Cape Canaveral, FL, Canaveral Council of Technical Societies, 1984, p. 7-47 to 7-88.
(Contract NAS9-16715)

Several transportation system options that utilize the Space Station as a base for delivery of payloads to geosynchronous earth orbit are examined and compared to each other as well as to the reference case, which uses the orbiter as the staging base. The factors evaluated include impact on Kennedy Space Center (KSC) flow, STS traffic, load factor, and the cost effectiveness of each transportation system option. With respect to KSC flow, it is determined that utilizing the Space Station as a staging base could lead to a reduction of 3000 man-hours off-line and an additional 475 man-hours on-line. Launch costs for STS are reduced by 10 percent. The actual number of STS flights varies depending on the transportation system option, and the delivery of multiple payloads results in the least cost. C.D.

A85-41097
AN EVOLUTIONARY SPACE STATION ARCHITECTURE
O. P. HARWOOD British Interplanetary Society, Journal (Space Stations) (ISSN 0007-084X), vol. 38, July 1985, p. 305-314.

A space station, an investment in permanent space occupancy, is justifiably concerned with evolutionary growth, adaptability and interchangeability. The system proposed here for its construction is based on the premise that whatever configuration is first launched will be found less satisfactory than envisaged in ground-based studies. At this point, rearrangement would be preferable to starting all over again. To assure construction of any shape (or any size) of assembly, the system is a trusswork of equal-length bars, habitable modules interchangeable with struts. There are six standard units and no adapters. The key element is a nodal sphere made from 12 identical sub-assemblies, each corresponding to a face of a bulged rhombic dodecahedron. Each port includes a berthing mechanism that allows lateral engagement. Habitable modules are integrally stiffened shells with standard patterns of attachment fittings for equipment installation, an extension of the concept that transformed a Saturn S-IVB stage into the Orbital Workshop of Skylab. External appendages (antennae, solar arrays, etc.) plug into ports in the nodes at the assembly's edges, while hangar spaces are multi-cell volumes inherent in the lattice. Clocking and identification of the port interfaces assure correct assembly. Not an alternate configuration, the construction system could build any of them. Author

A85-45399* National Aeronautics and Space Administration, Washington, D.C.
SYSTEMS VIEW OF POWER SYSTEMS AUTONOMY
J. L. ANDERSON (NASA, Washington, DC) IN: IECEC '84: Advanced energy systems - Their role in our future; Proceedings of the Nineteenth Intersociety Energy Conversion Engineering Conference, San Francisco, CA, August 19-24, 1984. Volume 1 . La Grange Park, IL, American Nuclear Society, 1984, p. 368-372. refs

A Space Station will involve the formation and sustained operation of an assembly of humans and machines in space for a period of 10-20 years. Technology and mission studies of a permanently manned, evolutionary Space Station have identified the need for automated and eventually some degree of autonomous systems operation. A Space Station power system will have a high degree of interaction with other onboard systems which will act as power loads. By examining the evolution of an operational power system from a systems viewpoint through increasing degrees of automation the system and technology requirements are identified for an evolutionary system. Author

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EXPERIMENTS, TETHERS, AND PLATFORMS

Includes descriptions and requirements of experiments and tethers onboard the Space Station and platforms that are either co-orbiting with the Space Station, in polar orbit, or in geosynchronous orbit and which are part of the Space Station system.

A85-34170
CALCULATION OF THE TEMPORAL SCATTERING CHARACTERISTICS OF RADAR TARGETS [VYCHISLENII VREMENNYKH KHARAKTERISTIK RASSEIANIIA RADIOLOKATSIONNYKH TSELEI]
V. I. KIRMASOV Radiotekhnika (ISSN 0033-8486), no. 3, March 1985, p. 16-19. In Russian. refs

A simple method for calculating the temporal scattering characteristics of radar targets is proposed which involves the calculation of the ramp function in the framework of the physical-optics approximation. The proposed method can be used to compile a catalog of target profile functions with the aim of target identification. In addition, the computed profile functions can be used as input data for simulating algorithms for the reconstruction of three-dimensional images of targets (e.g., tomography-based algorithms). Numerical results are compared with experimental data for the 1.08-10.8 GHz range. B.J.

A85-37173* National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
STS FLIGHT EXPERIMENTS DATA BASE
L. W. BRANTLEY, JR. (NASA, Marshall Space Flight Center, Huntsville, AL) IN: New opportunities in space; Proceedings of the Twenty-first Space Congress, Cocoa Beach, FL, April 24-26, 1984 . Cape Canaveral, FL, Canaveral Council of Technical Societies, 1984, p. 8-11 to 8-14.

In response to a request of the Space Station Task Force, a data base has been developed, utilizing experiment definitions from all NASA Centers, with emphasis on candidate STS flight experiments that relate to the development and operation of initial and growth versions of a Space Station. Experiments are also included for Shuttle enhancement, for servicing and operations of advanced vehicles such as OMV and OTV, for generic technology such as large structures, control and pointing, heat rejection, for life sciences and for physical sciences and applications. Criteria for selection activity are defined. Author

A85-37214
BISTATIC LIDAR EXPERIMENT PROPOSED FOR THE SHUTTLE/TETHERED SATELLITE SYSTEM MISSIONS
D. J. MCCOMAS, R. R. KARL, H. G. HORAK (Los Alamos National Laboratory, Los Alamos, NM), H. E. SPENCE (California, University, Los Angeles, CA), and T. D. WILKERSON (Maryland, University, College Park, MD) Review of Scientific Instruments (ISSN 0034-6748), vol. 56, May 1985, p. 670-673. Navy-supported research. refs

A new experiment concept has been proposed for the Shuttle/tethered satellite system missions, which can provide high-resolution, global density mappings of certain ionospheric species. The technique utilizes bistatic LIDAR to take advantage of the unique dual platform configuration offered by these missions. A tuned, Shuttle-based laser is used to excite a column of the atmosphere adjacent to the tethered satellite, while triangulating photometric detectors on the satellite are employed to measure the fluorescence from sections of the column. The fluorescent intensity at the detectors is increased about six decades over both ground-based and monostatic Shuttle-based LIDAR sounding of the same region. In addition, the orbital motion of the Shuttle provides for quasi-global mapping unattainable with ground-based observations. Since this technique provides such vastly improved resolution on a synoptic scale, many important middle atmospheric studies, heretofore untenable, may soon be addressed. Author

A85-39629*# Martin Marietta Aerospace, Denver, Colo.
A SPACE STATION TETHERED ORBITAL REFUELING FACILITY
D. A. FESTER, L. K. RUDOLPH, and E. R. KIEFEL (Martin Marietta Aerospace, Denver, CO) AIAA, SAE, ASME, and ASEE, Joint *Propulsion Conference*, 21st, *Monterey*, CA, July 8-10, 1985. 12 p. refs
(Contract NAS9-17059)
(AIAA PAPER 85-1160)

A planned function of the Space Station is to refurbish and refuel an advanced space-based LO2/LH2 orbit transfer vehicle. An alternative to propellant storage at the station is to use a remote facility tied to the station with a long tether. Preliminary design of such a facility is described with emphasis on fluid transfer and storage requirements. Using tether lengths of at least 300 ft, gravity gradient forces will dominate surface tension in such a system. Although gravity driven transfer is difficult because of line pressure drops, fluid settling over the tank outlet greatly alleviates acquisition concerns and will facilitate vented tank fills. The major concern with a tethered orbital refueling facility is its considerable operational complexity including transport of the OTV to and from the facility. Author

A85-40323#
X-BAND SAR CONCEPT FOR A JOINT MISSION WITH NASA'S SHUTTLE IMAGING RADAR [KONZEPT EINES X-BAND SAR FUER GEMEINSAME MISSION MIT DEM SHUTTLE IMAGING RADAR DER NASA]
H.-M. BRAUN and W. GILG (Dornier System GmbH, Friedrichshafen, West Germany) Deutsche Gesellschaft fuer Luft- und Raumfahrt, Jahrestagung, Hamburg, West Germany, Oct. 1-3, 1984. 20 p. In German.
(DGLR PAPER 84-105)

A concept for a Shuttle-borne SAR radar device for measurements in the X-band is described. The radar is designed to be able to operate as a German/Italian experiment in a joint mission with NASA devices operating in the L and C bands. Simultaneous observations in these bands permits the spectral back-scattering behavior of a variety of objects in the microwave range to be studied. All three devices have 12 m long, planar antenna arrays mounted together on a slewable support structure, permitting a wide range of variability with regard to frequencies, polarization, and direction of incidence. The height of operation is nominally 250 km. The X-band SAR has a geometric resolution of 30 m or less and a strip chart between 30 and 50 km. C.D.

A85-41095
DEDICATED REUSABLE SPACE PLATFORMS
D. E. KOELLE and W. KLEINAU (Messerschmitt-Boelkow-Blohm GmbH, Ottobrunn, West Germany) (British Interplanetary Society, European Space Symposium, 18th, London, England, June 1983) British Interplanetary Society, Journal (Space Stations) (ISSN 0007-084X), vol. 38, July 1985, p. 295-300.

Three designs are presented for different long-duration missions which could be carried out by Shuttle-carried dispersible/retrievable free-flying platforms (FFPs). FFPs are seen as an intermediate step and a supplement to space stations, and could serve for defining configurational, technological and operational requirements of larger space facilities. The SPAS-01 has already been borne by the Orbiter on missions 7 and 41B and validated many design systems. Material processing experiments could be performed on a FFP with a mirror furnace, solution growth facility, a protein growth facility, a multi-furnace assembly and an exobiological radiation assembly. Astronomical functions could be performed by another specialized platform, while a GEO-SPAS could perform a variety of remote sensing activities for e.g., mineral exploration, ocean monitoring and cartography. M.S.K.

A85-41096
SPACE STATION USERS
I. V. FRANKLIN (British Aerospace, PLC, Space and Communications Div., Bristol, England) British Interplanetary Society, Journal (Space Stations) (ISSN 0007-084X), vol. 38, July 1985, p. 301-304.

The ways various fields of space science, materials science, life sciences, earth sensing, communication, navigation and space technology will be served by the Manned Space Station (MSS) are described. The MSS complex will comprise the manned core station, unmanned platforms in co-orbit, polar orbit, and tethered to the core, MMUs, teleoperated maneuvering systems, and OTVs. The MSS will provide a platform and base for many space science observational instruments, materials science experiments, and deployment of polar orbiting remote sensing instruments. It is notable that the MSS must be built to habitable proportions before on-orbit experimentation can be carried out to refine designs and missions expected from further expansion of the MSS. M.S.K.

A85-41100* Jet Propulsion Lab., California Inst. of Tech., Pasadena.
SPACE PLATFORMS AND AUTONOMY
R. W. EASTER and R. L. STAEHLE (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) British Interplanetary Society, Journal (Space Stations) (ISSN 0007-084X), vol. 38, July 1985, p. 328-336. NASA-supported research. refs

Potential applications for autonomous space platforms (SP) are discussed. The platforms are assumed to have long in-service lifetimes and therefore be flexible as to configuration modification and payload changeout. Higher degrees of autonomy, particularly from ground control, are made possible because of the rapid increase of microprocessor power and artificial intelligence advances. Functioning independently, the platforms are to rely only on periodic refurbishment visits by, e.g., the Orbiter. The Manned Space Station (MSS) will be the most complex structure, involving multifacted man-machine interfaces. The SP can be subsystems of the MSS (or other platforms), handling communications enunciation, data acquisition, analysis and telemetry, fault detection and isolation, systems monitoring and control, etc. The SP adopted will depend in all cases on costs vs benefits analyses to determine the worth of removing the function(s) from direct, regular human intervention. M.S.K.

A85-42473*# Harvard-Smithsonian Center for Astrophysics, Cambridge, Mass.
GRAVITY GRADIOMETRY FROM THE TETHERED SATELLITE SYSTEM
G. E. GULLAHORN, M. D. GROSSI (Harvard-Smithsonian Center for Astrophysics, Cambridge, MA), and F. FULIGNI (Smithsonian Astrophysical Observatory, Cambridge, MA; CNR, Istituto di Fisica dello Spazio Interplanetario, Frascati, Italy) IEEE Transactions on Geoscience and Remote Sensing (ISSN 0196-2892), vol. GE-23, July 1985, p. 531-540. refs
(Contract NAG5-458; NAG5-338)

Measurement of the gradient of the gravitational acceleration from a satellite platform is likely to provide the next improvement in knowledge of the earth's gravity field after the upcoming Geopotential Research Mission (GRM). Observations from the subsatellite of a Tethered Satellite System (TSS) would increase sensitivity and resolution due to the low altitude possible. However, the TSS is a dynamically 'noisy' system and would be perturbed by atmospheric drag fluctuations. The dynamic noise is being modeled in order to evaluate the feasibility of TSS gradiometry and to design methods of abating the error caused by this noise. The demonstration flights of the TSS will provide an opportunity to directly observe the dynamical environment and refine modeling techniques. Author

A85-45818
SATELLITE SAILING
J. PEARSON Spaceflight (ISSN 0038-6340), vol. 27, Sept.-Oct. 1985, p. 362, 363.

Tethers are being designed for a variety of uses; one such plan developed by NASA is a tether for satellite sailing in order to change the Shuttle's orbit and enhance satellite launching, retrieving, and repair. A lifting body would be extended on the tether from the Shuttle down far enough into the upper atmosphere to create aerodynamic lift; this would cause the sail to move and the Shuttle's orbit to change. The sail would need to be as large as the area of the Shuttle and be lowered to 80-100 km in order to change the orbital plane of the Shuttle by several degrees per day. The tether could also be used to create a wind tunnel of up to 25 times the speed of sound in which experiments could be performed. I.F.

A85-46504
THE EUROSTAR PLATFORM
G. T. HORRITT (British Aerospace, PLC, Space and Communication Div., Stevenage, England) British Interplanetary Society, Journal (Space Technology) (ISSN 0007-084X), vol. 38, Sept. 1985, p. 401-405.

Eurostar has been designed jointly by British Aerospace and Matra of Toulouse as a middle-of-the-range, long-life, versatile platform compatible with PAM D, PAM DII and shared Ariane. This paper describes the subsystems in detail and shows that the highly accurate body pointing capability, payload mass capacity of 200-350 kg and end of life power of 2.5 kW enables the platform to meet a variety of direct broadcast television and telecommunications requirements. It points at the highly efficient bi-propellant system, certain other novel features and the minimal amount of ground control required, all of which add up to considerable operational flexibility. Author

A85-47029*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
THE DEFINITION OF THE SHUTTLE TETHERED AEROTHERMODYNAMIC RESEARCH FACILITY
P. M. SIEMERS, III, G. M. WOOD, JR. (NASA, Langley Research Center, Hampton, VA), H. WOLF, P. F. FLANAGAN, and M. W. HENRY (Analytical Mechanics Associates, Inc., Hampton, VA) AIAA, Atmospheric Flight Mechanics Conference, 12th, Snowmass, CO, Aug. 18-21, 1985. 15 p. refs
(AIAA PAPER 85-1794)

Studies have been conducted to define the feasibility and practical limitations of the Shuttle Orbiter Tethered 'wind-tunnel' concept. This concept, referred to as the Shuttle Tethered Aerothermodynamic Research Facility (STARFAC), is proposed to provide researchers access to altitudes above 90 km to accomplish aerothermodynamic research in the rarefied upper atmosphere. Determining the feasibility and limitations of the concept has required the enhancement and/or development of mission simulation analytical techniques and control laws; the accomplishment of candidate mission simulations; the definition of instrumentation requirements, both for science and engineering; and the establishment of tether and satellite design requirements to meet STARFAC objectives. The results of the study, to date, indicate that such a concept is both feasible and practical. Representative results are presented, as are recommendations for continued studies which would result in program implementation. Author

N85-22462*# Martin Marietta Corp., Denver, Colo. Space Systems Div.
SELECTED TETHER APPLICATIONS IN SPACE: PHASE 2. EXECUTIVE SUMMARY Final Report
M. H. THORSON and L. J. LIPPY Feb. 1985 23 p
(Contract NAS8-35499)
(NASA-CR-171421; NAS 1.26:171421; MCR-85-1309) Avail: NTIS HC A02/MF A01 CSCL 22B

The application of tether technology has the potential to increase the overall performance efficiency and capability of the integrated space operations and transportation systems through the decade of the 90s. The primary concepts for which significant economic benefits were identified are dependent on the space station as a storage device for angular momentum and as an operating base for the tether system. Concepts examined include: (1) tether deorbit of shuttle from space station; (2) tethered orbit insertion of a spacecraft from shuttle; (3) tethered platform deployed from space station; (4) tether-effected rendezvous of an OMV with a returning OTV; (5) electrodynamic tether as an auxiliary power source for space station; and (6) tether assisted launch of an OTV mission from space station. A.R.H.

N85-22463*# Martin Marietta Corp., Denver, Colo. Space Systems Div.
SELECTED TETHER APPLICATIONS IN SPACE: PHASE 2 Final Report
M. H. THORSEN and L. J. LIPPY Feb. 1985 138 p
(Contract NAS8-35499)
(NASA-CR-171422; NAS 1.26:171422; MCR-85-1308) Avail: NTIS HC A07/MF A01 CSCL 22B

System characteristics and design requirements are assessed for tether deployment. Criteria are established for comparing alternate concepts for: (1) deployment of 220 klb space shuttle from the space station; (2) tether assisted launch of a 20,000 lb payload to geosynchronous orbit; (3) placement of the 20,000 lb AXAF into 320 nmi orbit via orbiter; (4) retrieval of 20,000 lb AXAF from 205 nmi circular orbit for maintenance and reboost to 320 nmi; and (5) tethered OMV rendezvous and retrieval of OTV returning from a geosynchronous mission. Tether deployment systems and technical issues are discussed. A.R.H.

N85-22521*# California Univ., San Diego, La Jolla. Dept. of Physics.
PRELIMINARY INVESTIGATION OF THE ELECTRODYNAMICS OF A CONDUCTING TETHER
W. B. THOMPSON *In* NASA. Lewis Research Center Spacecraft Environ. Interactions Technol., 1983 p 649-662 Mar. 1985 refs Sponsored in part by Martin Marietta Aerospace Corp.
Avail: NTIS HC A99/MF E03 CSCL 22B

An introductory study of the properties of an electrically conducting tether flown from the shuttle is presented. Only a single configuration is considered: a vertical conductor moving normally across the Earth's field, connecting the shuttle to a large conducting balloon that passively extracts electrons from the ionosphere. The distortions in the plasma at maximum current collection are described, as are the local and distant wakes. Numerical values are given. B.W.

N85-23814*# National Aeronautics and Space Administration, Washington, D.C.
NASA MOBILE SATELLITE PROGRAM
G. KNOUSE and W. WEBER (JPL, California Inst. of Tech., Pasadena) *In* NASA. Langley Research Center Large Space Antenna Systems Technol., 1984 p 1-25 Apr. 1985
Avail: NTIS HC A20/MF A01 CSCL 22B

A three phase development program for ground and space segment technologies which will enhance and enable the second and third generation mobile satellite systems (MSS) is outlined. Phase 1, called the Mobile Satellite Experiment (MSAT-X), is directed toward the development of ground segment technology needed for future MSS generations. Technology validation and preoperational experiments with other government agencies will be carried out during the two year period following launch. The satellite channel capacity needed to carry out these experiments will be obtained from industry under a barter type agreement in exchange for NASA provided launch services. Phase 2 will develop and flight test the multibeam spacecraft antenna technology needed to obtain substantial frequency reuse for second generation commercial systems. Industry will provide the antenna, and NASA will fly it on the Shuttle and test it in orbit. Phase 3 is similar to Phase 2 but will develop an even larger multibeam antenna and test it on the space station. M.G.

N85-23858*# Eastman Kodak Co., Rochester, N. Y.
LARGE DEPLOYABLE REFLECTOR (LDR) REQUIREMENTS FOR SPACE STATION ACCOMMODATIONS
D. A. CROWE, M. J. CLAYTON, and F. C. RUNGE (McDonnell, Douglas Astronautics Co., Huntington Beach, Calif.) *In* NASA. Langley Research Center Large Space Antenna Systems Technol., 1984, Pt. 2 p 775-791 Apr. 1985 refs
Avail: NTIS HC A21/MF A01 CSCL 22B

Top level requirements for assembly and integration of the Large Deployable Reflector (LDR) Observatory at the Space Station are examined. Concepts are currently under study for LDR which will provide a sequel to the Infrared Astronomy Satellite and the Space Infrared Telescope Facility. LDR will provide a spectacular capability over a very broad spectral range. The Space Station will provide an essential facility for the initial assembly and check out of LDR, as well as a necessary base for refurbishment, repair and modification. By providing a manned platform, the Space Station will remove the time constraint on assembly associated with use of the Shuttle alone. Personnel safety during necessary EVA is enhanced by the presence of the manned facility. B.W.

N85-23860*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
SPACE-BASED ANTENNA MEASUREMENT SYSTEM CONCEPTS FOR SPACE STATION OPERATION
C. L. CUCCIA, T. G. CAMPBELL, W. L. PRITCHARD (Satellite Systems Engineering, Inc., Bethesda, Md.), and J. LYON (Howland Co., Inc., Atlanta, Ga.) *In its* Large Space Antenna Systems Technol., 1984, Pt. 2 p 809-843 Apr. 1985
Avail: NTIS HC A21/MF A01 CSCL 22B

The capability to make functional checks of communications satellites in low Earth orbit before boost to geosynchronous orbit as well as other near term radio frequency applications is discussed. On orbit measurement capability for the multitude of antennas and microwave systems for future space station operations is also discussed. Examples of radio frequency systems requirements for on orbit measurement capability are presented. E.R.

N85-23865*# Lockheed Missiles and Space Co., Sunnyvale, Calif.
SHUTTLE ATTACHED ANTENNA FLIGHT EXPERIMENT DEFINITION STUDY (FEDS)
G. J. HANNAN *In* NASA. Langley Research Center Large Space Antenna systems Technol., 1984, Pt. 2 p 909-928 Apr. 1985
Avail: NTIS HC A21/MF A01 CSCL 22B

The control algorithms, techniques, and hardware which would be required to support whether flight experiments of large space structures control are assessed for a 55-meter diameter wrap-rib reflector with a three degree-of-freedom gimbal. Strowman requirements were established for geometry, mass property, and elastic mode identification as well as for control and slewing. A five-body simulation of the Shuttle and test article was built with the ALLFLEX computer program. A maximum likelihood estimator, the flight experiment timeline, and the LSS control development test plan are discussed. A.R.H.

N85-23866*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
ELECTRO-SCIENCE REQUIREMENTS FOR SHUTTLE-ATTACHED ANTENNA FLIGHT EXPERIMENTS
W. L. GRANTHAM, E. M. BRACALENTE, and L. C. SCHROEDER *In its* Large Space Antenna Systems Technol., 1984, Pt. 2 p 929-947 Apr. 1985 refs
Avail: NTIS HC A21/MF A01 CSCL 22B

The activities of an in-house electro-science task group organized to conduct studies of shuttle-attached flight experiments using the 15-meter hoop-column antennas as a research tool for developing both improved sensor technology and LSA technology are described. Some experiments could provide significant amounts of scientific data such as radio star mapping and definition of ocean current eddies over limited geographic regions. The experiments originate from the microwave remote sensing community and other areas which require the inherently higher resolution and boresite gain of large space antennas. Technology experiments are also being studied which would use the 15-meter antenna experiments as a stepping stone to 50 to 100 meter class reflector technology in the future. An antenna technology experiment using the 15-meter antenna in a shuttle-attached mission is discussed. Electromagnetic modeling is correct for each major subsystem and also to verify the interrelations of the subsystems. A.R.H.

N85-23895# National Oceanic and Atmospheric Administration, Washington, D. C. National Environmental Satellite, Data and Information Service.
UTILIZATION OF THE POLAR PLATFORM OF NASA'S SPACE STATION PROGRAM FOR OPERATIONAL EARTH OBSERVATIONS
J. H. MCELROY and S. R. SCHNEIDER Sep. 1984 76 p refs (PB85-152502; NOAA-TR-NESDIS-12) Avail: NTIS HC A05/MF A01 CSCL 22B

Principal elements concerning the development of NASA's polar platform are discussed. The utilization of the platform in operational monitoring of the Earth's atmosphere, oceans, and land masses is discussed. The payload for the platform would include instruments derived from the current operational environmental satellites, ocean satellites that will be flown by several countries during the next decade, research programs and land satellite systems -- both governmental and commercial. These instruments may justify two polar-orbiting, Sun-synchronous, astronaut-serviced platforms. The platforms would be at an altitude in the range from 700 to 900 kilometers and be at two equatorial crossing times, one early in the morning between 8:30 and 10:30 A.M. southbound and the second near noon, perhaps at 1:00 P.M. northbound. GRA

N85-26343# Erno Raumfahrttechnik G.m.b.H., Bremen (West Germany). Hauptabt. Vorprojekte und Studien.
STUDY ON THE EXTENSION OF EXPERIMENT RESOURCES IN THE MAUS PROJECT Final Report, Nov. 1983
H. ANDERLE, G. BOERCHERS, G. FECHNER, V. GROTH, B. HAASE, H. STOLZE, and P. VITS Bonn Bundesministerium fuer Forschung und Technologie Dec. 1984 61 p In GERMAN; ENGLISH summary Sponsored by Bundesministerium fuer Forschung und Technologie
(BMFT-FB-W-84-051; ISSN-0170-1339) Avail: NTIS HC A04/MF A01; Fachinformationszentrum, Karlsruhe, West Germany DM 12

Concepts for the extensions of the MAUS-experiment-resource-limits were analyzed. The limits for the experiment parameters such

as volume, mass, energy and dissipation are increased by connecting several get away special (GAS) containers to MAUS-clusters. The analyzed concepts are discussed and for one selected concept the development phase is prepared by the design of hardware, by electronic layouts and by planning of the procurement (with working scheme and schedule). Author (ESA)

N85-26597*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
A BRIEF DESCRIPTION OF THE TWO PRIMATE EXPERIMENTS TO BE CARRIED OUT ON SL-4
L. ELSEA *In its* NASA Ames Summer High School Apprenticeship Res. Program p 41-44 Apr. 1985 refs
Avail: NTIS HC A06/MF A01 CSCL 22A

Two primate experiments to be carried on Spacelab 4 are discussed. One of these investigates thermoregulation of primates during altered gravity. In previous ground-based tests, primate heat distribution was shown to change during centrifugation (a way of subjecting subjects to higher-than-Earth gravity), the inner body cooling off and the skin temperature rising. The adaptive and homeostatic mechanisms triggered by spaceflight are studied. Ways in which to correct any undesirable shifts in the homeostatic capabilities of the thermoregulatory control system are addressed. The other experiment involving primates addressess the changes in fluid distribution and electrolyte content of blood that occur in spaceflight. During previous space missions, fluid shifts from the legs to the chest and head have been noted. Ground-based studies have shown decreases in blood potassium levels and increases in potassium excretion. B.W.

N85-26852*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
SPACE STATION SPARTAN STUDY Final Report
J. H. LANE, J. R. SCHULMAN, and W. M. NEUPERT Jul. 1985 183 p
(NASA-TM-86215; REPT-85F0220; NAS 1.15:86215) Avail: NTIS HC A09/MF A01 CSCL 22B

The required extension, enhancement, and upgrading of the present Spartan concept are described to conduct operations from the space station using the station's unique facilities and operational features. The space station Spartan (3S), the free flyer will be deployed from and returned to the space station and will conduct scientific missions of much longer duration than possible with the current Spartan. The potential benefits of a space station Spartan are enumerated. The objectives of the study are: (1) to develop a credible concept for a space station Spartan; and (2) to determine the associated requirements and interfaces with the space station to help ensure that the 3S can be properly accommodated. E.A.K.

N85-27325*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
SIMULTANEOUS EARTH OBSERVATIONS FROM 2 SATELLITES
H. E. MONTGOMERY Jul. 1985 7 p refs
(NASA-TM-86204; REPT-85B0288; NAS 1.15:86204) Avail: NTIS HC A02/MF A01 CSCL 05B

Simultaneous co-located observations from two different orbits lead to several advantages (i.e., cross calibration of sensors and a wider range of solar-zenith and sensor look angles). The question was asked how many times per year (on the average) do the sub-satellite points of two satellites simultaneously come within D kilometers of each other?. For the Space Station (altitude: 500 km, inclination: 28 deg) and a Sun synchronous satellite (altitude 705 km, inclination 98.21 deg) the answers are 16, 41 and 82 times per year for encounter distances D of 20, 50, and 100 km espectively. The relationship between encounters per year and distance D is linear. The answers were obtained in two ways: (1) a closed form statistical approach which led to a simple algebraic expression, and (2) a Monte Carlo type computer solution. The largest difference between the two solutions was less than 12%. Author

N85-27923*# Ball Aerospace Systems Div., Boulder, Colo.
SHUTTLE-TETHERED SATELLITE SYSTEM DEFINITION STUDY EXTENSION Final Report
30 Jun. 1980 295 p
(Contract NAS8-32853)
(NASA-CR-171473; NAS 1.26:171473; F80-10) Avail: NTIS HC A13/MF A01 CSCL 22A

A system requirements definition and configuration study (Phase B) of the Tethered Satellite System (TSS) was conducted during the period 14 November 1977 to 27 February 1979. Subsequently a study extension was conducted during the period 13 June 1979 to 30 June 1980, for the purpose of refining the requirements identified during the main phase of the study, and studying in some detail the implications of accommodating various types of scientific experiments on the initial verification flight mission. An executive overview is given of the Tethered Satellite System definition developed during the study. The results of specific study tasks undertaken in the extension phase of the study are reported. Feasibility of the Tethered Satellite System has been established with reasonable confidence and the groundwork laid for proceeding with hardware design for the verification mission. B.W.

N85-27924*# Ball Aerospace Systems Div., Boulder, Colo. Systems and Antennas Organization.
SHUTTLE-TETHERED SATELLITE SYSTEM DEFINITION STUDY. VOLUME 1: EXECUTIVE STUDY Final Study Report
Feb. 1979 72 p
(Contract NAS8-32853)
(NASA-CR-171474; NAS 1.26:171474; DRMA-05-VOL-1; DPD-544-VOL-1) Avail: NTIS HC A04/MF A01 CSCL 22A

The Tethered Satellite System has great prospects for extending orbital operations capability of the Space Transportation System to science, applications, and technology projects not otherwise attainable. The system will installed in the Shuttle Orbiter and will have the capability to deploy a captive satellite up to 100 km away from the Orbiter. Control and retrieval of the satellite are accomplished by means of a tether line connecting the satellite and the cargo bay mounted equipment in the Orbiter. At low satellite altitudes, the system will permit investigations of a duration that could not be pursued with sounding rockets of free-flying spacecraft. The propose of the Shuttle/Tethered Satellite System Definition Study was to produce the preliminary design, preliminary specifications, gross program plans, and program cost estimate for a 1982 operational verification flight. This was accomplished during a fifteen month effort under by the NASA George C. Marshall Space Flight Center (MSFC). The MSFC Phase 1 and related studies demonstrated the feasibility of the system and served as a starting point for the Phase 2 definition study. B.W.

N85-28893*# Lockheed Missiles and Space Co., Palo Alto, Calif.
LONG LIFE FEASIBILITY STUDY FOR THE SHUTTLE INFRARED TELESCOPE FACILITY
Jun. 1985 185 p
(Contract NAS2-11155)
(NASA-CR-3722; NAS 1.26:3722; LMSC-D877125) Avail: NTIS HC A09/MF A01 CSCL 03A

A study was conducted to assess the feasibility of designing an Infrared Telescope of the 1 meter class which would operate effectively as a Shuttleborne, 14-day Spacelab payload and then be adapted with little modification to work as a 6 month Space station or free flyer payload. The optics configuration and requirements from a previous study were used without modification. In addition, an enhancement to 2 year mission lengths was studied. The cryogenic system selected was a hybrid design with an internal solid Hydrogen tank at 8 Kelvin and an internal superfluid tank at 2K. In addition to the cryogenic design, a detailed look at secondary mirror actuators for chopping, focus and decenter was conducted and analysis and cryo test reported. Author

N85-29553*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
ATMOSPHERE MONITORING REQUIREMENTS
M. RUECKER *In its* Proc. of the Seminar on Space Station Human Productivity 29 p Mar. 1985
Avail: NTIS HC A99/MF E03 CSCL 06T

Atmospheric monitoring needs and requirements associated with the use of the Mass Spectrometer Electro-Optical Ion Detector for space stations contamination studies are discussed. Instrument performance requirements and design specifications are examined. A general overview is presented of the types of chemical contaminants found in spacecraft environments. B.W.

N85-31140*# Old Dominion Univ., Norfolk, Va. Dept. of Chemical Sciences.
QUASI NON-INTRUSIVE SAMPLING AND ANALYSIS OF GASES ASSOCIATED WITH THE BOUNDARY LAYER ON THE TETHERED SATELLITE AND SIMILAR SUPERSONIC AND HYPERSONIC RESEARCH VEHICLES Final Report, 1 May 1984 - 30 Apr. 1985
C. FISHEL, S. NIEDERRITER, and K. G. BROWN Jun. 1985 80 p refs
(Contract NAS1-17099)
(NASA-CR-176075; NAS 1.26:176075) Avail: NTIS HC A05/MF A01 CSCL 22B

The effect that one candidate inlet, an assembly of capillary openings in a thin glass plate (a multichannel plate), might have on the overall sampling process is considered. The flow characteristics of the plate, under a variety of conditions of external pressure and mass flow, is evaluated. A review of capillary flow theory is presented with some development of the pertinent equations. The predicted mass flow will be compared to that determined perimentally to assess the effect that mass flow through one capillary might have upon a neighboring capillary. Mass spectrometric measurements of mixtures flowing through the multichannel plate (MCP) is also considered. In the first part of the experiments, the flow was in a direction normal to the surface of the plate. The experimental gases were Argon and mixtures of carbon dioxide in air. Ongoing experiments are discussed which are conducted with the flow parallel to the surface of the plate, a simulation of the kind of flow that a flight vehicle would experience. Author

N85-31221# Consiglio Nazionale delle Ricerche, Frascati (Italy). Ist. di Fisica dello Spazio Interplanetario.
SHUTTLE MOLECULAR GUN: SMOG. POTENTIAL EXPERIMENT FOR THE ELECTRODYNAMIC TETHERED SATELLITE SYSTEM (TSS) MISSION
G. MASTRANTONIO Oct. 1984 17 p refs
(IFSI-84-17) Avail: NTIS HC A02/MF A01

The Shuttle Molecular Gun for the Tethered Satellite System electrodynamic experiment consists of a facility complement to perform active and interactive experiments on and in the Earth's ionosphere. The viability of the critical ionization velocity concept can be verified in a selected space situation. However, other uses (e.g., measurement of accomodation coefficient and scattering angles between high speed molecules and a solid surface, study of chemical reaction at high kinetic energies) which may have equal importance in their own right but which fall outside the area of space plasma physics are also possible. Author (ESA)

N85-33182# National Oceanic and Atmospheric Administration, Washington, D. C. National Environmental Satellite, Data, and Information Service.
THE SPACE STATION POLAR PLATFORM: NOAA SYSTEMS CONSIDERATIONS AND REQUIREMENTS
J. H. MCELROY and S. R. SCHNEIDER Jun. 1985 168 p refs
(NOAA-TR-NESDIS-22; PB86-109246) Avail: NTIS HC A08/MF A01

The systems considerations that must be taken into account for NOAA to utilize the Polar Platform are presented. Issues addressed include overall systems configuration, instrument assemblies, support subsystems, communication links, servicing, orbits, altitudes, ground data processing, archiving of data, international participation, and organizational roles and responsibilities. Author

N85-34154*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
THE ROLE OF TETHERS ON SPACE STATION
G. VONTIESENHAUSEN, ed. Oct. 1985 155 p refs
(NASA-TM-86519; NAS 1.15:86519) Avail: NTIS HC A08/MF A01 CSCL 22B

The results of research and development that addressed the usefulness of tether applications in space, particularly for space station are described. A well organized and structured effort of considerable magnitude involving NASA, industry and academia have defined the engineering and technological requirements of space tethers and their broad range of economic and operational benefits. The work directed by seven NASA Field Centers is consolidated and structured to cover the general and specific roles of tethers in space as they apply to NASA's planned space station. This is followed by a description of tether systems and operations. A summary of NASA's plans for tether applications in space for years to come is given. Author

N85-34158*# Alabama Univ., Huntsville.
COORDINATED STUDY OF SOLAR-TERRESTRIAL PAYLOADS ON SPACE STATION Interim Status Report, 10 Jul. 1984 - 31 Jul. 1985
S. T. WU 1985 53 p refs Proc. of the Solar Terrestrial Observatory Mini-Workshop, Huntsville, Ala., 6 Jun. 1985
(Contract NAS8-488)
(NASA-CR-176160; NAS 1.26:176160) Avail: NTIS HC A04/MF A01 CSCL 14B

A review of the instruments to be placed on the initial Solar Terrestrial Observatory (STO) is given. Brief descriptive writeups of each instrument are included. The placement of these instruments is discussed.

N85-34159*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
SOFT X-RAY TELESCOPE (SXRT) Abstract Only
R. L. MOORE *In* Alabama Univ. Coordinated Study of Solar-Terrestrial Payloads on Space Station 2 p 1985
Avail: NTIS HC A04/MF A01 CSCL 14B

The soft X-ray telescope (SXRT) will provide direct images of the solar corona with spatial resolution of about 1 arcsecond. These images will show the global structure of the corona, the location and area of coronal holes, and the presence of even the smallest active regions and flares. The good spatial resolution will show the fine scale magnetic structure and changes in these phenomena. These observations are essential for monitoring, predicting, and understanding the solar magnetic cycle, coronal heating, solar flares, coronal mass ejections, and the solar wind. These observations complement those of the White Light Coronagraph and Ultra-Violet Coronal Spectrometer; the SXRT will detect active regions and coronal holes near the east limb, thereby giving a week or more of advanced warning for disturbed geomagnetic conditions at Earth. The instrument consists of a grazing incidence collecting mirror with a full disk film camera at the primary focus, and a secondary relay optic that feeds a CCD camera with a field of view about the size of an average active region. Author

N85-34160*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
SOLAR ULTRAVIOLET SPECTRAL IRRADIANCE MONITOR (SUSIM) Abstract Only
R. L. MOORE *In* Alabama Univ. Coordinated Study of Solar-Terrestrial Payloads on Space Station 2 p 1985
Avail: NTIS HC A04/MF A01 CSCL 14B

The solar ultraviolet spectral irradiance monitor (SUSIM) measures the ultraviolet flux from the entire Sun with high absolute accuracy over the wavelength range 120 to 400 nm with a resolution

of 0.1 nm. SUSIM consists of two identical double dispersion scanning spectrometers with 5 photodiodes, 2 photon counters, and a deuterium lamp calibration source, all sealed in a canister pressurized to 1.1 atmosphere of argon. One spectrometer is used almost continuously during sunlight, the other is used once per day as a calibration check. The observations will yield improved absolute measurements of the ultraviolet solar fluxes, provide an accurate reference for studies of variability of the solar fluxes on the time scales of the solar cycle and longer, and measure shorter term changes as well. These measurements complement the active cavity radiometer (ACR) measurements of the total solar irradiance. The data will be used to study the physical behavior of the Sun and the Earth's atmosphere, weather, and climate. Author

N85-34161*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
WHITE LIGHT CORONOGRAPH (WLC) AND ULTRA-VIOLET CORONAL SPECTROMETER (UVCS) Abstract Only
R. L. MOORE *In* Alabama Univ. Coordinated Study of Solar-Terrestrial Payloads on Space Station 2 p 1985
Avail: NTIS HC A04/MF A01 CSCL 14B

The white light coronagraph (WLC) and ultraviolet coronal spectrometer (UVCS) together reveal the corona and the roots of the solar wind from 1.5 to 6 solar radii from Sun center. The WLC measures the plasma density and spatial structure of the corona and coronal mass ejections at a resolution of about 20 arcseconds. The UVCS, in combination with the WLC, measures the temperature and radial outflow speed of the coronal plasma. These instruments will detect mass ejections from active regions and high speed solar wind streams from coronal holes a few days before the source regions rotate onto the face of the Sun, thus giving a week or more of advanced warning for disturbed geomagnetic conditions at Earth. Author

N85-34162*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
HIGH RESOLUTION TELESCOPE AND SPECTROGRAPH (HRTS) Abstract Only
R. L. MOORE *In* Alabama Univ. Coordinated Study of Solar-Terrestrial Payloads on Space Station 2 p 1985
Avail: NTIS HC A04/MF A01 CSCL 14B

The major objectives of the high resolution telescope and spectrograph (HRTS) are: (1) the investigation of the energy balance and mass balance of the temperature minimum, chromosphere, transition zone, and corona in quiet regions on the Sun as well as in plages, flares, and sunspots; (2) the investigation of the velocity field of the lower corona to study the origin of the solar wind; (3) the investigation of preflare and flare phenomena. The HRTS instruments consists of a telescope, an ultraviolet spectrograph, and ultraviolet spectroheliograph, and an H alpha slit display system, all housed in a thermal control canister mounted on an instrument pointing system. Author

N85-34163*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
ACTIVE CAVITY RADIOMETER (ACR) Abstract Only
R. L. MOORE *In* Alabama Univ. Coordinated Study of Solar-Terrestrial Payloads on Space Station 2 p 1985
Avail: NTIS HC A04/MF A01 CSCL 14B

The active cavity radiometer (ACR) measures the total solar irradiance to determine the magnitude and direction of variations in the total solar radiative output. The ACR is an electrically self calibrating cavity pyroheliometer capable of measuring the total solar irradiance with an absolute accuracy better than 0.2% and capable of detecting changes in the total irradiance smaller than 0.001%. The data will be used to study the physical behavior of the Sun and the Earth's climate. Author

N85-34165*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
SPACE EXPERIMENTS WITH PARTICLE ACCELERATORS (SEPAC) Abstract Only
W. T. ROBERTS *In* Alabama Univ. Coordinated Study of Solar-Terrestrial Payloads on Space Station 2 p 1985
Avail: NTIS HC A04/MF A01 CSCL 14B

The space experiments with particle accelerators (SEPAC) instruments consist of an electron accelerator, a plasma accelerator, a neutral gas (N2) release device, particle and field diagnostic instruments, and a low light level television system. These instruments are used to accomplish multiple experiments: to study beam particle interactions and other plasma processes; as probes to investigate magnetospheric processes; and as perturbation devices to study energy coupling mechanisms in the magnetosphere, ionosphere, and upper atmosphere. Author

N85-34166*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
THEORETICAL AND EXPERIMENTAL BEAM PLASMA PHYSICS (TEBPP) Abstract Only
W. T. ROBERTS *In* Alabama Univ. Coordinated Study of Solar-Terrestrial Payloads on Space Station 2 p 1985
Avail: NTIS HC A04/MF A01 CSCL 14B

The theoretical and experimental beam plasma physics (TEBPP) consists of a package of five instruments to measure electric and magnetic fields, plasma density and temperature, neutral density, photometric emissions, and energetic particle spectra during firings of the particle injector (SEPAC) electron beam. The package is deployed on a maneuverable boom (or RMS) and is used to measure beam characteristics and induced perturbations in the near field (10 m) and mid field (10 m to 100 m) along the electron beam. The TEBPP package will be designed to investigate induced oscillations and induced electromagnetic mode waves, neutral and ion density and temperature effects, and beam characteristics as a function of axial distance. Author

N85-34167*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
RECOVERABLE PLASMA DIAGNOSTICS PACKAGE (RPDP) Abstract Only
W. T. ROBERTS *In* Alabama Univ. Coordinated Study of Solar-Terrestrial Payloads on Space Station 2 p 1985
Avail: NTIS HC A04/MF A01 CSCL 14B

The recoverable plasma diagnostics package (RPDP) is an ejectable and recoverable satellite with flight and ground support systems so that it can be utilized in three modes: attached to an remote manipulator system; tethered; or as a subsatellite. The satellite is well instrumented with particle and field diagnostic as well as optical sensors to: investigate the dynamics of the natural environment or ejected perturbations from particle beams; measure the characteristics and propagation of electrostatic and electromagnetic waves; study wave particle interactions; and study natural properties of the magnetosphere, ionosphere, and upper atmosphere. Author

N85-34168*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
ELECTRODYNAMIC TETHER Abstract Only
W. T. ROBERTS *In* Alabama Univ. Coordinated Study of Solar-Terrestrial Payloads on Space Station 2 p 1985
Avail: NTIS HC A04/MF A01 CSCL 22B

The electrodynamic tether consists of a satellite deployed to a distance of 20 km by an electrically conducting tether. The space station hardware consists of a 12 meter deployment boom, satellite cradle, tether reel and motor, and other tether support systems. The electrodynamic tether will be used to perform a variety of wave experiments by exciting a wide spectrum of low frequency waves in the ionospheric plasma. The system can also be used to artificially generate and study field aligned currents and associated plasma effects. Hydromagnetic waves generated by the passage of the system through the space plasma are of particular interest in space plasma research. Author

N85-34169*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
IMAGING SPECTROMETRIC OBSERVATORY (ISO) Abstract Only
W. T. ROBERTS *In* Alabama Univ. Coordinated Study of Solar-Terrestrial Payloads on Space Station 2 p 1985
Avail: NTIS HC A04/MF A01 CSCL 14B

The imaging spectrometric observatory (ISO) is discussed. The objectives of this instrument are to measure the spectral signatures of a large range of minor constituents, metastable, and excited species of both atomic and molecular ions, and neutrals in the atmosphere (from the stratosphere to the upper thermosphere). The instrument is composed of five identical spectrometers, each restricted to a given spectral range between 20 and 1200 nanometers designed for high speed operation as an imaging device. Each module is an imaging scanning spectrometer with coincident 0.5 x 0.007 degree field of view. Author

N85-34172*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
WIDE ANGLE MICHELSON DOPPLER IMAGING INTERFEROMETER (WAMDII) Abstract Only
W. T. ROBERTS *In* Alabama Univ. Coordinated Study of Solar-Terrestrial Payloads on Space Station 2 p 1985
Avail: NTIS HC A04/MF A01 CSCL 14B

The wide angle Michelson Doppler imaging interferometer (WAMDII) is a specialized type of optical Michelson interferometer working at sufficiently long path difference to measure Doppler shifts and to infer Doppler line widths of naturally occurring upper atmospheric Gaussian line emissions. The instrument is intended to measure vertical profiles of atmospheric winds and temperatures within the altitude range of 85 km to 300 km. The WAMDII consists of a Michelson interferometer followed by a camera lens and an 85 x 106 charge coupled device photodiode array. Narrow band filters in a filter wheel are used to isolate individual line emissions and the lens forms an image of the emitting region on the charge coupled device array. Author

N85-34173*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
VEHICLE CHARGING AND POTENTIAL (VCAP) Abstract Only
W. T. ROBERTS *In* Alabama Univ. Coordinated Study of Solar-Terrestrial Payloads on Space Station 2 p 1985
Avail: NTIS HC A04/MF A01 CSCL 14B

The vehicle charging and potential (VCAP) payload includes a small electron accelerator capable of operating in a pulsed mode with firing pulses ranging from 600 nanoseconds to 107 seconds (100 milliamps at 1000 volts), a spherical retarding potential analyzer - Langmuir probe, and charge current probes. This instrumentation will support studies of beam plasma interactions and the electrical charging of the spacecraft. Active experiments may also be performed to investigate the fundamental processes of artificial aurora and ionospheric perturbations. In addition, by firing the beam up the geomagnetic field lines of force (away from the Earth) investigations of parallel electric field may be performed. Author

N85-34174*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
INITIAL PLACEMENT OF STO INSTRUMENTS
In Alabama Univ. Coordinated Study of Solar-Terrestrial Payloads on Space Station 19 p 1985 refs
Avail: NTIS HC A04/MF A01 CSCL 14B

The current plans for the placement of the Solar Terrestrial Observatory (STO) space station will make use of each of the currently planned space station elements - the manned space station, the polar platform, and the coorbiting platform. A designation of the instrument placement on each element along with a summary of the mass, volume, power and data requirements which these instrument will impose is provided in tabular form. R.J.F.

N85-34977*# New Mexico Univ., Albuquerque. Dept. of PHysics and Astronomy.
DETECTION OF 10 (1) GEV COSMIC NEUTRINOS WITH A SPACE STATION
J. LINSLEY *In* NASA. Goddard Space Flight Center 19th Intern. Cosmic Ray Conf., Vol. 3 p 438-441 Aug. 1985 refs (OG-9.4-10) Avail: NTIS HC as boxed set only $200/MF A01 per volume or E99 per entire set CSCL 03B

The potential value of SOCRAS (Space Observatory of Cosmic Ray Air Showers) for studying the highest energy cosmic rays, including the neutrinos produced in collisions of cosmic ray protons with photons of the 3 deg background radiation is examined. This instrument would look down at the atmosphere from a space station orbiting the Earth at an altitude of 500 to 600 km. During the night portion of each orbit, air showers would be imaged in the fluorescent light they produce. Progress toward the eventual realization of this scheme is described, including a suggestion by Torii for improving the vertical resolution, measurements of the terrestrial background light by Halverson, and especially an application of the LPM effect, expected to increase the sensitivity for upward moving neutrinos by several orders of magnitude. Author

N85-34984*# New Mexico Univ., Albuquerque. Dept. of Physics and Astronomy.
ASTROPHYSICAL APPLICATIONS OF HIGH ANGULAR RESOLUTION ARRAY-TELESCOPES
J. LINSLEY *In* NASA. Goddard Space Flight Center 19th Intern. Cosmic Ray Conf., Vol. 3 p 465-468 Aug. 1985 refs (OG-9.5-7) Avail: NTIS HC as boxed set only $200/MF A01 per volume or E99 per entire set CSCL 03B

The air shower array-telescopes which are currently being used to search for and study point sources of UHE gamma-rays have angular resolution similar to 1 deg, limited by either the small total area of particle detectors or poor timing resolution. As the signal to noise ratio depends sensitively on the angular resolution, it seems certain that this figure will quickly be surpassed when second generation instruments come into operation. Since the trajectories of galactic cosmic rays with E 100,000 GeV are practically straight lines on scales of 1 A.U. or less, these new instruments will be able to observe a shadow cast by the Moon (angular diameter 0.5 deg). Although the angular diameter of the Sun is practically the same, its shadow will be more complex because of its magnetic field. Thus, high angular resolution observations of the Sun afford a means of investigating the solar magnetic field, and also the charge composition of cosmic rays, including the ratio of antiprotons to protons. Author

N85-35218# National Environmental Satellite Service, Washington, D. C.
SPACE STATION POLAR PLATFORM: INTEGRATING RESEARCH AND OPERATIONAL MISSIONS
J. H. MCELROY and S. R. SCHNEIDER Jan. 1985 27 p (PB85-195279; NOAA-TR-NESDIS-19) Avail: NTIS HC A03/MF A01 CSCL 22B

This report describes how an operational payload proposed by NOAA for the Space Station Polar Platform may be merged together with the research sensors scheduled to be carried on the Platform as part of NASA's Earth Observing System (EOS). This is the third in a series of NOAA/NESDIS Technical Reports on the space station project. Issues addressed include studies of solar terrestrial interactions, as well as monitoring of the Earth's atmosphere, oceans and land masses using both operational and R&D sensors. GRA

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OPERATIONS SUPPORT

Includes descriptions of models, analyses and trade studies of maneuvers, performance, support, and EVA and/or IVA servicing requirements of Space Station systems such as the OMV and OTV, and experiments.

A85-31050* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
OPTIMAL IMPULSIVE MANOEUVRES AND AERODYNAMIC BRAKING
D. J. JEZEWSKI (NASA, Johnson Space Center, Houston, TX) *Optimal Control Applications and Methods* (ISSN 0143-2087), vol. 6, Jan.-Mar. 1985, p. 1-11. refs

A method developed for obtaining solutions to the aerodynamic braking problem, using impulses in the exoatmospheric phases is discussed. The solution combines primer vector theory and the results of a suboptimal atmospheric guidance program. For a specified initial and final orbit, the solution determines: (1) the minimum impulsive cost using a maximum of four impulses, (2) the optimal atmospheric entry and exit-state vectors subject to equality and inequality constraints, and (3) the optimal coast times. Numerical solutions which illustrate the characteristics of the solution are presented. M.D.

A85-32349
SIMULATING SATELLITE RETRIEVAL MISSIONS USING THE MANNED MANEUVERING UNIT
C. HARTLEY (Martin Marietta Aerospace, Denver, CO) Journal of Environmental Sciences (ISSN 0022-0906), vol. 28, Mar.-Apr. 1985, p. 29-33. Previously announced in STAR as N84-34490.

Details of the Manned Maneuvering Unit (MMU) and its use is discussed. MMU simulations in the Space Operations Simulator (SOS) use two major devices. The first is a six-degree-of-freedom moving base carriage that allows the trainee freedom to fly the MMU in a large room and to match rates and dock with full scale targets. The second device is a large screen television display that provides the trainee with accurate views of tumbling targets from any point in a surrounding sphere up to 300 meters (1000 feet) in diameter. Astronauts used the SOS to train for the Solar Max repair mission and are now using it to train for a mission to recover the Palapa-B communications satellite. Subjective comparisons by astronauts of an orbit MMU performance to simulated MMU performance in the SOS indicate that the simulations are very realistic. Data from the Solar Max mission have resulted in two software upgrades that increase SOS fidelity for the next MMU mission: a model of contact dynamics between the MMU and a target spacecraft, and a model of MMU plume impingement forces during docking. Author

A85-33723
SPACE STATION EXTRAVEHICULAR ACTIVITY (EVA) OPERATIONAL CONSIDERATIONS
B. BOSWELL (McDonnell Douglas Corp., Houston, TX) AIAA, SAE, ASME, AIChE, and ASMA, Intersociety Conference on Environmental Systems, 14th, San Diego, CA, July 16-19, 1984. 9 p.
(SAE PAPER 840970)

The issues of importance in the development of Space Station EVAs are identified, and their impact on the provision of the baseline EVA capability and on the analysis required for proper allocation of functions between IVA (intravehicular activity) and EVA is assessed. The impact of EVA on the requirements for spacecraft design, equipment, power, logistics, and costs is also discussed, taking into consideration potential benefits of advances in technology. L.T.

A85-33724
EVA - PLANNED OR CONTINGENCY
R. J. DELLACAMERA (McDonnell Douglas Astronautics Co., Huntington Beach, CA) AIAA, SAE, ASME, AIChE, and ASMA, Intersociety Conference on Environmental Systems, 14th, San Diego, CA, July 16-19, 1984. 8 p.
(SAE PAPER 840971)

The reality of the Space Shuttle and the prospect of a permanent Space Station have caused system developers to look again at extravehicular activity (EVA) as a viable means of assembling and servicing orbiting space hardware. This paper considers the kinds of analyses required to assess man's possible role in the extravehicular environment of these systems. The paper covers analysis and planning of EVA in the development, deployment, and operational stages of a program. Through examples, benefits in the form of cost avoidance and risk reduction are illustrated. Author

A85-33725
ASTRONOMICAL AND SORTIE PAYLOAD EVA OPERATIONS
H. T. FISHER (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) AIAA, SAE, ASME, AIChE, and ASMA, Intersociety Conference on Environmental Systems, 14th, San Diego, CA, July 16-19, 1984. 15 p.
(SAE PAPER 840972)

Greater numbers of spacecraft and payloads are being developed for on-orbit astronomical viewing and data acquisition. Based on cost savings potentials, more consideration is now being given to on-orbit servicing and associated crew operations. Accordingly, integration of crew functions at program onset and continuing throughout the development phases becomes essential to aid in achieving mission success. Through cross coupling of these crew operations and associated equipment, simulations, and training with standard classes and families of spacecraft, substantial cost benefits to a variety of programs can be realized. Thus, can be established a logical and proven crew operations data and performance base for the future. Author

A85-35392*# Martin Marietta Aerospace, Denver, Colo.
BENEFITS OF A REUSABLE UPPER STAGE ORBITAL MANEUVERING VEHICLE
G. T. KRONCKE (R&D Associates, Colorado Springs; Martin Marietta Aerospace, Denver, CO) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 22, May-June 1985, p. 351-354. Previously cited in issue 18, p. 2645, Accession no. A83-39107. refs
(Contract NAS8-34581)

A85-37169* *National Aeronautics and Space Administration.* Marshall Space Flight Center, Huntsville, Ala.
ORBITAL MANEUVERING VEHICLE (OMV) MISSIONS APPLICATIONS AND SYSTEMS REQUIREMENTS
W. G. HUBER and D. C. CRAMBLIT (NASA, Marshall Space Flight Center, Huntsville, AL) IN: New opportunities in space; Proceedings of the Twenty-first Space Congress, Cocoa Beach, FL, April 24-26, 1984 . Cape Canaveral, FL, Canaveral Council of Technical Societies, 1984, p. 7-10 to 7-46.

The routine delivery of large payloads to low earth orbit has become a reality with the Space Transportation System (STS). However, once earth orbit has been achieved, orbit transfer operations represent an inefficient use of the Space Shuttle. The Orbital Maneuvering Vehicle (OMV) will add a new and needed dimension to STS capabilities. Utilized in a reusable manner, the OMV is needed to deliver and retrieve satellites to and from orbital altitudes or inclinations beyond the practical limits of the Space Shuttle and to support basic Space Station activities. The initial OMV must also be designed to permit the addition of future mission kits to support the servicing, module changeout, or refueling of satellites in Low Earth Orbit (LEO) and Geostationary Earth Orbit (GEO), and the retrieval and deorbit of space debris. This paper addresses the mission needs along with the resulting performance implications, design requirements and operational capabilities imposed on the OMV planned for use in the late 1980s. Author

A85-37580*# North Carolina State Univ., Raleigh.
A REVIEW OF SOME APPROXIMATE METHODS USED IN AERODYNAMIC HEATING ANALYSES
F. R. DEJARNETTE (North Carolina State University, Raleigh, NC), H. H. HAMILTON, K. J. WEILMUENSTER (NASA, Langley Research Center, Space Systems Div., Hampton, VA), and F. M. CHEATWOOD American Institute of Aeronautics and Astronautics, Thermophysics Conference, 20th, Williamsburg, VA, June 19-21, 1985. 11 p. refs
(AIAA PAPER 85-0906)

It is pointed out that preliminary design and optimization studies for new aerospace vehicles require techniques which can calculate aerodynamic heating rates accurately and efficiently. The method employed to calculate the flow field depends to a large extent on the shape of the vehicle, Mach number, Reynolds number, and Knudsen number. In the case of the aero-assisted orbital transfer vehicle (AOTV), a substantial portion of the flight will be in the transitional regime between continuum and free molecule flow. The present paper discusses some approximate methods which have been used to calculate heating rates on high-speed vehicles. Attention is given to the stagnation point and leading edges, the downstream region, the axisymmetric analog, laminar and turbulent heating rates, transition heating rates, gas models, and three-dimensional applications. G.R.

A85-37617*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
ORBITAL RESUPPLY OF LIQUID HELIUM
P. KITTEL (NASA, Ames Research Center, Space Technology and Systems Branch, Moffett Field, CA) American Institute of Aeronautics and Astronautics, Thermophysics Conference, 20th, Williamsburg, VA, June 19-21, 1985. 9 p. NASA-supported research. refs
(AIAA PAPER 85-0959)

The ability to resupply scientific instruments in orbit with liquid helium would greatly enhance several planned missions. These missions include the SIRTF (Space Infrared Telescope Facility), the LDR (Large Deployable Reflector), the GP-B (Gravity Probe - B), and include individual instruments on the HST (Hubble Space Telescope), and on the AXAF (Advanced X-ray Astrophysics Facility). Resupply in orbit would extend the lifetimes of these missions without the difficulties, the delays, and the costs that are associated with retrieving the system, resupplying these systems on the ground, and relaunching. This is especially true of systems, such as the LDR, that are assembled in space and thus would be difficult to return to earth. This paper presents a conceptual design of a Helium Resupply System (HERS) and a discussion of the transfer efficiency. Author

A85-37619*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
SYSTEMS ANALYSIS AND TECHNOLOGY DEVELOPMENT FOR THE NASA ORBIT TRANSFER VEHICLE
B. B. ROBERTS (NASA, Johnson Space Center, Missions and Projects Office, Houston, TX) American Institute of Aeronautics and Astronautics, Thermophysics Conference, 20th, Williamsburg, VA, June 19-21, 1985. 12 p. refs
(AIAA PAPER 85-0965)

The benefits derived from aerobraking technology development for the Orbit Transfer Vehicle (OTV) are analyzed. The relative advantages of several other candidate OTV technologies are evaluated, and a relative ranking on the basis of performance considerations is presented. It is shown that aerobraking technologies can provide significant cost reductions for delivery of payloads to geosynchronous orbit, and that new and unique design concepts for OTVs must be pursued in order to realize the promised cost benefits. The goal for an aerobraked vehicle is an upper limit of 20 percent of the vehicle devoted to aero systems. Practical OTV configurations based on a concept of integrated structural design that can achieve this goal are suggested. A concept for a flight experiment to acquire the data needed to advance the discussed aeroassist technologies is proposed. C.D.

A85-37673*# Informatics General Corp., Palo Alto, Calif.
OPTIMUM CONFIGURATION OF HIGH-LIFT AEROMANEUVERING ORBITAL TRANSFER VEHICLES IN VISCOUS FLOW
C. B. DAVIES (Informatics General Corp., Palo Alto, CA) and C. PARK (NASA, Ames Research Center, Moffett Field, CA) American Institute of Aeronautics and Astronautics, Thermophysics Conference, 20th, Williamsburg, VA, June 19-21, 1985. 17 p. refs
(AIAA PAPER 85-1059)

The results of an analysis to determine the geometrical configuration of an aeroassisted transfer vehicle with a high lift-to-drag ratio (L/D) are described and the constraints imposed on this type of entry vehicle are considered. The aerodynamic characteristics of three configurations, a flat-plate delta wing, a truncated straight cone, and a truncated bent biconic are compared. The effect of viscosity is included in the analysis which examines the rounding of the sharp leading edges. It is shown that, under the constraints of carrying a given volume in the dead air region, the values of L/D are similar for each configuration and that a small blunt leading edge only slightly affects each vehicle's aerodynamic performance, causing less than a 5 percent drop in L/D. The truncated bent biconic is found to be the only configuration that provides the necessary stabilizing moments. M.D.

A85-38447*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
DESIGN STUDY OF A SLANT-NOSE-CYLINDER AEROASSISTED ORBITAL TRANSFER VEHICLE
M. L. BLOSSER, R. W. POWELL, L. R. JACKSON, C. I. CRUZ (NASA, Langley Research Center, Hampton, VA), S. J. SCOTTI, and J. A. CERRO (Kentron Technical Center, Hampton, VA) American Institute of Aeronautics and Astronautics, Thermophysics Conference, 20th, Williamsburg, VA, June 19-21, 1985. 14 p. refs
(AIAA PAPER 85-0966)

A slant-nose-cylinder aeroassisted orbital transfer vehicle configuration is described and analyzed in this study. The vehicle is sized for a 12,000 lb roundtrip payload between low earth orbit and geosynchronous orbit and is assumed to be space based. The vehicle can be fabricated using near-term technologies and is fully reusable. Optional advanced technologies offer potential for improved performance. The vehicle can be assembled on the ground and carried to orbit in the Shuttle cargo bay. An enclosed payload bay is provided in the vehicle to protect payloads during the pass through the atmosphere. The payload bay capacity can be increased from a 10 ft to a 14 ft diameter payload by replacing a modular section of the payload bay in space. The results of calculations used to size the vehicle and to predict its performance and weight are presented. Author

A85-38449*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
THERMAL DESIGN OF AOTV HEATSHIELDS FOR A CONICAL DRAG BRAKE
W. C. PITTS (NASA, Ames Research Center, Moffett Field, CA) and M. S. MURBACH (Informatics General Corp., Palo Alto, CA) American Institute of Aeronautics and Astronautics, Thermophysics Conference, 20th, Williamsburg, VA, June 19-21, 1985. 12 p. refs
(AIAA PAPER 85-1052)

Results are presented from an on-going study of the thermal performance of thermal protection systems for a conical drag brake type AOTV. Three types of heatshield are considered: rigid ceramic insulation, flexible ceramic blankets, and ceramic cloths. The results for the rigid insulation apply to other types of AOTV as well. Charts are presented in parametric form so that they may be applied to a variety of missions and vehicle configurations. The parameters considered include: braking maneuver heat flux and total heat load, heatshield material and thickness, heatshield thermal mass and conductivity, absorptivity and emissivity of surfaces, thermal mass of support structure, and radiation transmission through thin heatshields. Results of temperature

calculations presented show trends with and sensitivities to these parameters. The emphasis is on providing information that will be useful in estimating the minimum required mass of these heatshield materials. Author

A85-38943*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
RADIOMETER EXPERIMENT FOR THE AEROASSIST FLIGHT EXPERIMENT
W. C. DAVY, C. PARK, J. O. ARNOLD (NASA, Ames Research Center, Moffett Field, CA), and A. BALAKRISHNAN (Eloret Institute, Sunnyvale, CA) American Institute of Aeronautics and Astronautics, Thermophysics Conference, 20th, Williamsburg, VA, June 19-21, 1985. 10 p. refs
(AIAA PAPER 85-0967)

A forthcoming NASA flight experiment is described that provides an opportunity to obtain a large base of radiometric data for high-altitude, high-velocity thermochemically nonequilibrated-flow conditions. As a preliminary to the design of a radiometer for this experiment, an approximate method for predicting both equilibrium and nonequilibrium radiative surface fluxes is described. Spectral results for one trajectory state, a velocity of 10 km/sec at an altitude of 85 km, are presented. These results are then used to develop some of the instrument parameters that will be needed for designing of the three genre of radiometers that are proposed for this experiment. Author

A85-38946*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
HYPERSONIC MERGED-LAYER FLOW ON A SPHERE
A. C. JAIN (NASA, Langley Research Center, Space Systems Div., Hampton, VA; Indian Institute of Technology, Kanpur, India) American Institute of Aeronautics and Astronautics, Thermophysics Conference, 20th, Williamsburg, VA, June 19-21, 1985. 10 p. refs
(AIAA PAPER 85-1031)

With the objective to achieve the desired reduction in velocity by aerodynamic forces, an aeroassisted orbital transfer vehicle (AOTV) is expected to fly in the higher region of the atmosphere for a sustained period of time. This aeroassist maneuver will occur in the transitional regime, if the vehicle is designed for a low ballistic coefficient. In this case, a merged-layer (ML) is formed around the space vehicle. The flow characteristics of the vehicle can be studied by making use of the full Navier-Stokes (NS) equations, taking into account slip and temperature jump conditions. The present investigation has the objective to obtain a two-term series solution of the full Navier-Stokes equations with surface slip and temperature jump conditions for the ML flow on a sphere. Attention is given to the mathematical formulation of the problem, the numerical method of integration, and the results. G.R.

A85-38948*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
ELECTRON-IMPACT VIBRATIONAL EXCITATION RATES IN THE FLOW FIELD OF AEROASSISTED ORBITAL TRANSFER VEHICLES
J.-H. LEE (NASA, Ames Research Center, Computational Chemistry and Aerothermodynamics Branch, Moffett Field, CA) American Institute of Aeronautics and Astronautics, Thermophysics Conference, 20th, Williamsburg, VA, June 19-21, 1985. 18 p. refs
(AIAA PAPER 85-1035)

This paper examines the vibrational excitation rate processes expected in the flow field of aeroassisted orbital transfer vehicles (AOTVs). An analysis of the multiple-quantum vibrational excitation processes by electron impact is made to predict the vibrational excitation cross sections, rate coefficients, and relaxation times which control vibrational temperature. The expression for the rate of electron-vibration energy transfer is derived by solving the system of master equations which account for the multiple-level transitions. The vibrational excitation coefficients, which are the prerequisite physical quantities in solving the obtained vibrational equation, are calculated based on the theoretically predicted cross sections. These cross sections are obtained from quantum mechanical calculations, based on the concept that vibrational excitation of molecules by electron impact occurs through formation of an intermediate negative ion state. Finally, the modified Landau-Teller-type rate equation, which is suitable for the numerical calculations for the AOTV flow fields, is suggested. Author

A85-38949*# San Jose State Univ., Calif.
AOTV BOW SHOCK LOCATION
D. DESAUTEL (San Jose State University, San Jose, CA) American Institute of Aeronautics and Astronautics, Thermophysics Conference, 20th, Williamsburg, VA, June 19-21, 1985. 10 p. refs
(Contract NCA2-OR-675-401)
(AIAA PAPER 85-1062)

Hypersonic bow-shock location and geometry are of central importance to the aerodynamics and aerothermodynamics of aeroassisted orbital transfer vehicles (AOTVs), but they are difficult to predict for a given vehicle configuration. This paper reports experimental measurements of shock standoff distance for the 70 deg cone AOTV configuration in shock-tunnel-test flows at Mach numbers of 3.8 to 7.9 and for angles of attack from 0 deg to 20 deg. The controlling parameter for hypersonic bow-shock standoff distance (for a given forebody shape) is the mean normal-shock density ratio. Values for this parameter in the tests reported are in the same range as those of the drag-brake AOTV perigee regime. Results for standoff distance are compared with those previously reported in the literature for this AOTV configuration. It is concluded that the AOTV shock standoff distance for the conical configuration, based on frustrum (base) radius, is equivalent to that of a sphere with a radius about 35 percent greater than that of the cone; the distance is, therefore, much less than reported in previous studies. Some reasons for the discrepancies between the present and previous are advanced. The smaller standoff distance determined here implies there will be less radiative heat transfer than was previously expected. Author

A85-39268* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
SPACE SHUTTLE MISSION EXTENSION CAPABILITY
W. M. FRASER, JR. (NASA, Johnson Space Center, Houston, TX) IN: Space systems technology; Proceedings of the Aerospace Congress and Exposition, Long Beach, CA, October 15-18, 1984 . Warrendale, PA, Society of Automotive Engineers, Inc. (SAE SP-593), 1984, p. 167-171.
(SAE PAPER 841620)

Space Shuttle missions are currently limited to 11 days, primarily due to depletion of the power reactants (hydrogen and oxygen). A power system Mission Extension Kit (MEK) is described which could provide the capability to stay on orbit 10 additional days. These extra days would benefit Space Station construction and missions such as materials processing, earth and celestial observation, and life science studies (Spacelab). Other constraints to longer missions which may dictate minor Orbiter modifications will be discussed. The power system MEK is particularly desirable because of its existing flight qualified hardware which can be delivered within 3 to 4 years. Author

A85-39560*# Texas Univ., Austin.
MINIMUM ENERGY-LOSS GUIDANCE FOR AEROASSISTED ORBITAL PLANE CHANGE
D. G. HULL, J. M. GILTNER, J. L. SPEYER, and J. MAPAR (Texas, University, Austin, TX) (Guidance and Control Conference, Seattle, WA, August 20-22, 1984, Technical Papers, p. 19-26) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 8, July-Aug. 1985, p. 487-493. Previously cited in issue 21, p. 3006, Accession no. A84-43404. refs
(Contract NAS7-100)

A85-39653#
UNIQUE REQUIREMENTS DRIVE DESIGN OF OTV TANKAGE
W. P. HAESE (Martin Marietta Aerospace, Michoud Div., New Orleans, LA) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 21st, Monterey, CA, July 8-10, 1985. 8 p.
(AIAA PAPER 85-1203)

Designs, performance and mission profiles for an orbital transfer vehicle (OTV) under development are summarized. The cryogenically-fuelled vehicle would be reusable and function between LEO and GEO. Its launch would be either from the base of the STS main tank or from the Space Station. The return to LEO after payload deployment in GEO would include use of an aerobrake to shed velocity and shield the OTV against heat damage. The cost of the OTV is driven by the weight, which in turn drives the propellant requirements. The tank skin thickness reaches a minimum at the threshold of weldability, although meteoroid protection will also be necessary. M.S.K.

A85-39733*# Rockwell International Corp., Canoga Park, Calif.
CRYOGENIC UPPER STAGE TEST BED ENGINE
R. PAUCKERT, A. ZACHARY, E. DEGAETANO, and R. SUTTON (Rockwell International Corp., Rocketdyne Div., Canoga Park, CA) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 21st, Monterey, CA, July 8-10, 1985. 11 p.
(Contract NAS3-23773)
(AIAA PAPER 85-1339)

A vehicle system with unique characteristics will be needed in connection with the extension of the Space Transportation System (STS) from Low Earth Orbit (LEO) to Geosynchronous Equatorial Orbit (GEO) and beyond. These characteristics are determined by NASA missions related to the deployment of large space structures, satellite servicing, and manned sorties to geosynchronous orbit. Advances in vehicle design and operation will be required along with significant advances in engine technologies. A versatile, well-instrumented test bed engine will be needed for the evaluation of the required technologies. Developments leading to the fabrication and assembly of the first high chamber pressure expander cycle test bed engine are discussed. The test bed engine, which is called Integrated Component Evaluator (ICE), is required for the development of an advanced, cryogenic, upperstage engine. G.R.

A85-40336#
ROBUS - A RETRIEVABLE SYSTEM OF SHUTTLE-OPTIMIZED PLATFORMS [ROBUS - EIN RUECKFUEHRBARES SYSTEM SHUTTLE-OPTIMIERTER PLATTFORMEN]
N. PAILER (Dornier System GmbH, Friedrichshafen, West Germany) Deutsche Gesellschaft fuer Luft- und Raumfahrt, Jahrestagung, Hamburg, West Germany, Oct. 1-3, 1984. 23 p. In German.
(DGLR PAPER 84-120)

The 'one-way' satellite, which can only be employed once, represents the classical concept of a satellite in the field of extraterrestrial research. A transformation of current space research projects, utilizing an earth orbit, into commercial operations requires the employment of more cost-effective payload carriers. It is pointed out that the era of multiply-usable platforms has begun. A West German aerospace company meets this challenge with a concept of free-flying platforms which is implemented with the aid of the Robus (Retrievable Orbiting BUS) system. The disk-like Robus configuration has been designed with the aim to minimize the costs of a launching with the aid of the Space Shuttle. The employment of three different types of Robus units is considered. Robus-1 represents a retrievable multipurpose platform for technological missions, while Robus-2 and Robus-3 are intended for astronomical long-term missions. In the case of Robus-3, an autonomous propulsion system is used to make the platform independent from the Shuttle orbit. G.R.

A85-40802*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
EXPERIMENTAL AND ANALYTICAL DERIVATION OF ARC-HEATER SCALING LAWS FOR SIMULATING HIGH-ENTHALPY ENVIRONMENTS FOR AEROASSISTED ORBITAL TRANSFER VEHICLE APPLICATION
W. WINOVICH, J. BALBONI (NASA, Ames Research Center, Moffett Field, CA), and A. BALAKRISHNAN (Eloret Institute, Sunnyvale, CA) American Institute of Aeronautics and Astronautics, Thermophysics Conference, 20th, Williamsburg, VA, June 19-21, 1985. 11 p. refs
(AIAA PAPER 85-1006)

The computer code ARCFLO II was used as a guide to increase the performance of the Interaction Heating Facility at Ames Research Center. A closed-form scaling law relation was derived that provides an understanding of the factors that affect enthalpy in the constricted-arc heater. From a study of this scaling law, it is concluded that at constant pressure, enthalpy is proportional to current density raised to the 0.60 power for current densities from 80 to 150 A/sq cm. At constant current density, enthalpy is inversely proportional to pressure to the nth power, where n varies from 0.14 to 0.43, depending on the current density. Radiative heat losses are responsible for the falloff in performance at combinations of high current density and high pressure. An analytical, closed form scaling law based on a constant-temperature arc-core model agrees qualitatively with the scaling law deduced from ARCFLO II. C.D.

A85-43065
CERTAIN PROBLEMS ASSOCIATED WITH THE WELDING OF THIN-SHEET METAL IN SPACE [NEKOTORYE PROBLEMY SVARKI TONKOLISTOVOGO METALLA V KOSMOSE]
V. F. LAPCHINSKII Kosmicheskie Issledovaniia na Ukraine (ISSN 0321-4508), no. 18, 1984, p. 9-14. In Russian. refs

Results of an experimental study of the welding of thin (0.1-3 mm) sheets of aluminum, titanium, and other alloys used in spacecraft engineering, which has been conducted under conditions simulating those existing in space, are reviewed. Particular attention is given to the analysis of the factors leading to the formation of burn-through defects. Some welding techniques which make it possible to produce high-quality joints when welding thin-sheet metal with concentrated heat sources under conditions of microgravity are proposed. V.L.

A85-43863*# Michigan Univ., Ann Arbor.
EFFECT OF MAXIMUM LIFT TO DRAG RATIO ON OPTIMAL AEROASSISTED PLANE CHANGE
J. R. JOHANNESEN, N. X. VINH (Michigan, University, Ann Arbor), and K. D. MEASE (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) IN: Atmospheric Flight Mechanics Conference, 12th, Snowmass, CO, August 19-21, 1985, Technical Papers . New York, AIAA, 1985, p. 399-407. refs
(Contract JPL-956416)
(AIAA PAPER 85-1817)

The influence of the maximum lift-to-drag ratio on the turning performance of an Orbital Transfer Vehicle is analyzed. Chapman's variables are used to formulate the equations of motion which are valid for both atmospheric flight and flight in a vacuum in a Newtonian gravitational field. Of the six adjoint variables involved in the variational formulation, four exact integrals and two approximate relations are obtained. This leads to an approximate but explicit control law for the lift and bank control. The control law is tested numerically for a whole range of entry speeds, from parabolic entry to near-circular entry with several values of maximum lift-to-drag ratio. The extensive numerical results, which are very accurate as compared to the exact optimal values, show that the maximum plane change for any speed ratio V(entry)/V(final) is simply proportional to the maximum lift-to-drag ratio, and depends solely on this parameter. Author

A85-43864*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
ATMOSPHERIC GUIDANCE LAW FOR PLANAR SKIP TRAJECTORIES
K. D. MEASE and F. A. MCCREARY (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) IN: Atmospheric Flight Mechanics Conference, 12th, Snowmass, CO, August 19-21, 1985, Technical Papers . New York, AIAA, 1985, p. 408-415. NASA-supported research. refs
(AIAA PAPER 85-1818)

The applicability of an approximate, closed-form, analytical solution to the equations of motion, as a basis for a deterministic guidance law for controlling the in-plane motion during a skip trajectory, is investigated. The derivation of the solution by the method of matched asymptotic expansions is discussed. Specific issues that arise in the application of the solution to skip trajectories are addressed. Based on the solution, an explicit formula for the approximate energy loss due to an atmospheric pass is derived. A guidance strategy is proposed that illustrates the use of the approximate solution. A numerical example shows encouraging performance. Author

A85-43865*# Texas Univ., Austin.
NEW ANALYTICAL RESULTS FOR AOTV GUIDANCE
D. G. HULL (Texas, University, Austin) IN: Atmospheric Flight Mechanics Conference, 12th, Snowmass, CO, August 19-21, 1985, Technical Papers . New York, AIAA, 1985, p. 416-420.
(Contract NAS7-100)
(AIAA PAPER 85-1820)

Minimum energy-loss turns of an Aero-assisted, Orbital Transfer Vehicle (AOTV) performing the atmospheric portion of an orbital-plane-change maneuver are developed using the heading angle as the independent variable. Because the heading angle is monotonic, several difficulties previously encountered using the flight path angle, which is not monotonic, as the independent variable are eliminated. In addition, the solution of the optimal control problem reduces to the solution of a fourth-order polynomial which can be accomplished analytically. Author

A85-43942
PAVING THE WAY FOR SPACE TUGS
T. A. HEPPENHEIMER High Technology (ISSN 0277-2981), vol. 5, Sept. 1985, p. 57-59.

The Space Shuttle itself can fly no higher than a few hundred miles, while many spacecraft, such as, for example, the communication satellites, must go to a higher orbit. Currently NASA is relying on a variety of upper stages to place the spacecraft into the desired orbit. This approach has, however, a number of disadvantages. Contracts for initial studies on a space tug, or reusable orbital transfer vehicle (OTV), have, therefore, been awarded. The OTV is to have the capability to carry large payloads to geosynchronous orbit and beyond. An American aerospace company is studying the use of liquid hydrogen and liquid oxygen as propellants for the OTV. Another company has proposed the use of propellants which remain liquid at room temperature. A possible solution to the liquid hydrogen problem involves the use of a multilayer insulation for storing liquid hydrogen in space. The use of the OTV in connection with a lunar base is also considered. G.R.

A85-45743#
ROBUS - A RETRIEVABLE SYSTEM OF SPACE-SHUTTLE-OPTIMIZED PLATFORMS [ROBUS - EIN RUECKFUEHRBARES SYSTEM RAUMTRANSPORTER-OPTIMIERTER PLATTFORMEN]
N. PAILER, R. D. AUER, K. ECKARDT, G. RAUSCH, H. STOCKBURGER (Dornier System GmbH, Friedrichshafen, West Germany) et al. Luft- und Raumfahrt (ISSN 0173-0264), vol. 6, 2nd Quarter, 1985, p. 35-40. In German.

The reusable Space Shuttle provides an economic potential which together with the development of flexible and reusable multipurpose platforms will make it possible to conduct cost-efficient space missions. In response to the technical challenge presented by such platforms, a German aerospace company has developed the Robus (Retrievable Orbiting Bus) system, which has been designed with dimensions that ensure a transport in the Space Shuttle under optimized conditions. The three Robus configurations include Robus-1 for the conduction of technology missions, and Robus-2 and Robus-3 for long-term astronomical missions. Robus-3 has an autonomous propulsion system which makes the platform independent from the Shuttle orbit. Attention is given to the growth potential of Robus related to a Robus-4 version, details regarding the various telescopes intended for Robus, and aspects of platform maintenance with the aid of the Space Station. G.R.

A85-45902*# TRW, Inc., Redondo Beach, Calif.
THE ROLE OF ROBOTICS IN SPACE SYSTEM OPERATIONS
H. F. MEISSINGER and V. A. SPECTOR (TRW, Inc., Space and Technology Group, Redondo Beach, CA) IN: Guidance, Navigation and Control Conference, Snowmass, CO, August 19-21, 1985, Technical Papers . New York, AIAA, 1985, p. 223-236. refs
(Contract NAS8-35031)
(AIAA PAPER 85-1879)

The role of automation and robotics in support of man's activities in space is discussed, with emphasis given to satellite servicing functions on board the NASA Space Station (SS) or at remote locations. Consideration is given to four satellite servicing mission scenarios, including: low-earth-orbit (LEO) servicing of satellite in situ or on the Space Station following orbital transfer by means of an Orbital Maneuvering Vehicle (OMV); in situ servicing of a free-flying coorbiting materials processing platform; repair/refurbishment of Space Station payloads of substations; an in situ servicing of geostationary satellites by means of an Orbital Transfer Vehicle (OTV). The potential applications of three different automation technologies are examined, including: teleoperation; robotics; and artificial intelligence. Consideration is also given to the potential applications of the Space Station data system in support of servicing activities. A list of the more common terms of automation technology is provided. I.H.

A85-45933#
MANUALLY AUGMENTED PROXIMITY OPERATIONS AND DOCKING CONTROL
R. M. VAUGHAN and E. V. BERGMANN (Charles Stark Draper Laboratory, Inc., Cambridge, MA) IN: Guidance, Navigation and Control Conference, Snowmass, CO, August 19-21, 1985, Technical Papers . New York, AIAA, 1985, p. 518-528.
(AIAA PAPER 85-1941)

One key area of interest for future space missions is on-orbit proximity operations including the docking of two spacecraft. This paper presents four new capabilities for an experimental autopilot which extend the range of maneuvers available in this area. The process of docking is divided into four phases with specific objectives and requirements. An automated maneuver sequence for these phases is developed using the new capabilities. Results of two simulations of this sequence as implemented in the autopilot are given. Author

A85-45964*# Colorado Univ., Boulder.
OPERATIONAL IMPLICATIONS FOR PATH CONSTRAINED RENDEZVOUS
S. A. STERN (Colorado, University, Boulder) and K. M. SOILEAU (NASA, Johnson Space Center, Houston, TX) IN: Guidance, Navigation and Control Conference, Snowmass, CO, August 19-21, 1985, Technical Papers . New York, AIAA, 1985, p. 812-820. refs
(AIAA PAPER 85-1916)

After noting that many large orbiting space structures will be of such magnitude as to require proximity rendezvous guidance targeting in order to accomplish path-constrained approaches in the vicinity of their exterior surfaces, attention is given to the difficulties that inhere in the accomplishment of such rendezvous transfers due to physical constraints imposed by the structures' surfaces. Operationally feasible transfer techniques which circumvent the path constraints inherent in these maneuvers are discussed under the assumption of a number of restrictions. The

techniques presented may be important in asteroid exploration and exploitation. O.C.

A85-46999#
SPACECRAFT TRAJECTORY TARGETING BY BOUNDARY-CONDITION ORBIT FITTING
D. G. STUART AIAA Student Journal (ISSN 0001-1460), vol. 23, Spring 1985, p. 24-30, 33, 34. refs

A new method of determining a spacecraft trajectory target using boundary-condition orbit fitting was developed. The two-point orbital boundary value problem was extended to consider 3 of 4 parameters in determining the trajectory: velocity, altitude, flight path angle, and transfer angle. Two cases were studied to test the theory: (1) trajectory determination for a LEO to GEO transfer and (2) earth launch to LEO insertion. The results revealed that good targeting accuracy was possible with less than 0.001 percent error between the actual and desired target values; and delta-v values were close to optimal. This fast orbit fitting technique is easily implemented and can be applied to many two-body space-flight targeting problems. I.F.

N85-23857*# Lockheed Missiles and Space Co., Palo Alto, Calif. Research and Development Div.
UTILIZATION OF SPACE STATION BY THE LARGE DEPLOYMENT REFLECTOR
L. W. BANDERMANN and W. H. ALFF *In* NASA. Langley Research Center Large Space Antenna Systems Technol., 1984, Pt. 2 p 771-774 Apr. 1985 refs
Avail: NTIS HC A21/MF A01 CSCL 22B

The Large Deployable Reflector (LDR), a NASA concept of a very large, orbiting, far infrared submillimeter telescope is described. To be launched in the 1990s, LDR has a projected life of 10 years and is to be serviced every 2 to 3 years. A System Concept and Technology Definition Study of LDR for NASA Ames is currently being conducted. Study results indicate that launch of a 20 m LDR, operating in a 700 to 800 km orbit, requires two shuttle loads. The components of LDR are assembled in a lower parking orbit, and the system is checked out and then transferred to the operational orbit. Furthermore, for servicing, LDR may have to be retrieved to the same lower orbit (and later returned to operational altitude) by an orbit transfer vehicle. These requirements bring up the question of a suitable assembly, checkout, and servicing platform. The deployment process is time consuming and may require special equipment not necessarily available from the orbiter itself. The SS is an attractive choice for that platform. B.W.

N85-25330# Joint Publications Research Service, Arlington, Va.
PATON COMMENTS ON RESULTS OF SPACE WELDING TESTS Abstract Only
O. GUSEV *In its* USSR Rept.: Space (JPRS-USP-85-003) p 91 4 Mar. 1985 Transl. into ENGLISH from Pravda (USSR), 5 Nov. 1984 p 3
Avail: NTIS HC A08/MF A01

An assessment of space tests of an electron beam, hand held welding tool is given. Difficulties incurred in the use of the tool were attributed to the space environment and the fact that the process, though it had been practiced in an Earth pressure chamber, would present some initial difficulties in mastering. G.L.C.

N85-25376*# Scientific Systems, Inc., Cambridge, Mass.
AUTOMATIC RENDEZVOUS AND DOCKING SYSTEMS FUNCTIONAL AND PERFORMANCE REQUIREMENTS
1 Mar. 1985 16 p refs
(Contract NAS9-17274)
(NASA-CR-171866; NAS 1.26:171866; DRL-SE-1169T) Avail: NTIS HC A02/MF A01 CSCL 22B

A generalized mission design scheme which utilizes a standard mission profile for all OMV rendezvous operations, recognizes typical operational constraints, and minimizes propellant penalties due to nodal regression effects was developed. This scheme has been used to demonstrate a unified guidance and navigation maneuver processor (the UMP), which supports all mission phases through station-keeping. The initial demonstration version of the Orbital Rendezvous Mission Planner (ORMP) was provided for evaluation purposes, and program operation was discussed. G.L.C.

N85-26859# Air Force Inst. of Tech., Wright-Patterson AFB, Ohio.
OPTIMAL OPEN LOOP AND NONLINEAR FEEDBACK CONTROL FOR REMOTE ORBITAL CAPTURE Ph.D. Thesis
J. W. WIDHALM, JR. 1985 113 p
(AD-A151967; AFIT/CI/NR-85-32D) Avail: NTIS HC A06/MF A01 CSCL 22A

In this thesis optimal open loop aand nonlinear feedback control histories are presented for a problem of detumbling (passivating) a target satellite by a remotely operated robot spacecraft. Detumbling is required so that the robot spacecraft, sometimes called a teleoperator or orbital maneuvering vehicle (OMV), can return the target satellite to low-Earth orbit for servicing and repair. The dynamics of the coupled two-body system are described with equations of motion derived from an Eulerian formulation (the Hooker-Margulies equations). Two degrees of rotational freedom are allowed at the joint which connects the OMV and target spacecraft, and the joint is allowed to translate on the surface of the OMV. The initial condition of the axially symmetric target satellite is free spin and precession. Representative masses and inertias are assumed for each body. The detumbling controls, which are the external (thruster) and internal (joint) torques applied by the OMV, are found from optimal control theory yields a nonsingular two-point-boundary-value-problem which is solved numerically for the open loop controls over a specified time internal. Control constraints on the thrusters and one of the joint torques are also considered. Liapunov stability theory is used to derive a nonlinear feedback control which results in the asympototic stability of a set of equilibria for the two-body system. This control law is analyzed numerically and compared to the results of optimum open loop control. GRA

N85-29571*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
EXPERIENCES WITH NEUTRAL BUOYANCE TESTING MOCKUPS
B. DELLACAMERA *In its* Proc. of the Seminar on Space Station Human Productivity 9 p Mar. 1985
Avail: NTIS HC A99/MF E03 CSCL 05H

Contingency operations with neutral bouyancy simulation on a space platform is considered. Some task simulated are aft payload port deployment and retraction, removal and replacement of the control moment cyro, and deployment of the manual hand crank appendage. It is decided that crewmen can perform fine motor activities when simple aids are provided, certain tasks can be accomplished with less efforts when the crewman is afforded additional mobility, manual translation of large mass items is feasible, and that during the installation of replaceable units application of alignment indicators provide significant assistance to crewmen. E.R.

N85-30000*# TRW Space Technology Labs., Redondo Beach, Calif.
SPACE STATION AUTOMATION STUDY-SATELLITE SERVICING, VOLUME 2 Final Report, Jun. - Nov. 1984
H. F. MEISSINGER 20 Dec. 1984 134 p refs 2 Vol.
(Contract NAS8-35081)
(NASA-CR-171513; NAS 1.26:171513; Z-410.1-84-175-VOL-2)
Avail: NTIS HC A07/MF A01 CSCL 22B

Technology requirements for automated satellite servicing operations aboard the NASA space station were studied. The three major tasks addressed: (1) servicing requirements (satellite and space station elements) and the role of automation; (2) assessment of automation technology; and (3) conceptual design of servicing facilities on the space station. It is found that many servicing functions cloud benefit from automation support; and the certain research and development activities on automation technologies for servicing should start as soon as possible. Also; some advanced

automation developments for orbital servicing could be effectively applied to U.S. industrial ground based operations. J.W.G.

N85-30780*# National Aeronautics and Space Administration. *Ames Research Center, Moffett Field, Calif.*
NONEQUILIBRIUM AIR RADIATION (NEQUAIR) PROGRAM: USER'S MANUAL
C. PARK Jul. 1985 133 p refs
(NASA-TM-86707; REPT-85185; NAS 1.15:86707) Avail: NTIS HC A07/MF A01 CSCL 20H

A supplement to the data relating to the calculation of nonequilibrium radiation in flight regimes of aeroassisted orbital transfer vehicles contains the listings of the computer code NEQAIR (Nonequilibrium Air Radiation), its primary input data, and explanation of the user-supplied input variables. The user-supplied input variables are the thermodynamic variables of air at a given point, i.e., number densities of various chemical species, translational temperatures of heavy particles and electrons, and vibrational temperature. These thermodynamic variables do not necessarily have to be in thermodynamic equilibrium. The code calculates emission and absorption characteristics of air under these given conditions. Author

N85-31143*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
DOCKING SIMULATION ANALYSIS OF RANGE DATA REQUIREMENTS FOR THE ORBITAL MANEUVERING VEHICLE
J. D. MICHEAL and F. L. VINZ Apr. 1985 76 p refs
(NASA-TM-86510; NAS 1.15:86510) Avail: NTIS HC A05/MF A01 CSCL 22B

The results of an initial study are reported assess the controllability of the Orbital Maneuvering Vehicle (OMV) for terminal closure and docking are reported. The vehicle characteristics used in this study are those of the Marshall Space Flight Center (MSFC) baseline OMV which were published with the request for proposals for preliminary design of this vehicle. This simulation was conducted at MSFC using the Target Motion Simulator. The study focused on the OMV manual mode capability to accommodate both stabilized and tumbling target engagements with varying complements of range and range rate data displayed to the OMV operator. Four trained test subjects performed over 400 simulated orbital dockings during this study. A firm requirement for radar during the terminal closure and dock phase of the OMV mission was not established by these simulations. Fifteen pound thrusters recommended in the MSFC baseline design were found to be advantageous for initial rate matching maneuvers with unstabilized targets; however, lower thrust levels were desirable for making the final docking maneuvers. F.M.R.

N85-33145# Joint Publications Research Service, Arlington, Va.
PROSPECTIVE USES FOR DIFFUSION WELDING IN VACUUM Abstract Only
N. F. KAZAKOV *In its* USSR Rept.: Space (JPRS-USP-84-006) p 116 14 Nov. 1984 Transl. into ENGLISH from Krasnaya Zvezda (Moscow), 4 Aug. 1984 p 3
Avail: NTIS HC A08

The principles and features of diffusion welding in a vacuum, and some of the materials that can be welded most successfully by this method are outlined. A number of potential advantages for space welding operations, particularly the welding of metal structures are mentioned. The high vacuum of outer space and the use of the simplest devices to transmit compression pressure ensure reliable joining of various combinations of materials. It is suggested that the use of the diffusion method can shorten time for the repairing of space technology. E.A.K.

N85-33177*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
A REVIEW OF SHOCK WAVES AROUND AEROASSISTED ORBITAL TRANSFER VEHICLES
C. PARK Jun. 1985 33 p refs
(NASA-TM-86760; REPT-85277; NAS 1.15:86760) Avail: NTIS HC A03/MF A01 CSCL 22B

Aeroassisted orbital transfer vehicles (AOTVs) are a proposed type of reusable spacecraft that would be used to transport cargoes from one Earth-bound orbit to another. Such vehicles could be based on the proposed space station and used to transport commercial satellites from the space station to geostationary orbits or to polar orbits and return. During a mission, AOTVs would fly through Earth's atmosphere, thus generating aerodynamic forces that could be used for decelerating the vehicles or changing their direction. AOTV research findings were concerned with the shock-wave-induced, high-temperature airflows that would be produced around these vehicles during atmospheric flight. Special emphasis was placed on the problems of: (1) the chemical physics of multitemperature, ionizing, nonequilibrium air flows, and (2) the dynamics of the flows in the base region of a blunt body with complex afterbody geometry. Author

N85-34377*# Allied Bendix Aerospace, Mishawaka, Ind. Guidance Systems Div.
HARDWARE TEST PROGRAM FOR EVALUATION OF BASELINE RANGE-RANGE RATE SENSOR CONCEPT
E. R. FEAGLER Aug. 1985 119 p
(Contract NAS8-36144)
(NASA-CR-176143; NAS 1.26:176143; BGSD-MO-7035) Avail: NTIS HC A06/MF A01 CSCL 14B

During the past two and one-half years Bendix has been working with Marshall Space Flight Center (MSFC) on the conceptual design of an on-board sensor for application with the Orbital Maneuvering Vehicle (OMV). The proposed Range and Range Rate (R/R) sensor would aid the OMV in performing rendezvous and docking maneuvers by providing independent measurements of range, range rate, and bearing to a designated spacecraft target. The hardware Test Program was proposed as one of the steps of a development program which has the objective of providing the space qualified sensor required for this application. Through a series of analyses, to establish systems requirements and design definition, hardware modifications of Bendix brassboard radars to appropriate test bed configuration, and hardware testing, the program is designed to reduce technical risks associated with the R/R sensor design concept. A one-third scale model of the Hubble Space Telescope will be used as the target for these tests. Data generated by this signature measurements program will be utilized in formulating tracking algorithms for the extended target signature characteristic. R.J.F.

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SPACE ENVIRONMENT

Includes description of the space environment and effects on Space Station subsystems. Includes requirements for Space Station to accommodate this environment.

A85-33730
ABSORBED FLUX PREDICTIONS FOR SPACECRAFT IR TESTING
M. DONATO, C. RUEL, A. HARRIS (Spar Aerospace, Ltd., Sainte-Anne-de-Bellevue, Quebec, Canada), and B. MUIR (David Florida Laboratory, Ottawa, Canada) AIAA, SAE, ASME, AIChE, and ASMA, Intersociety Conference on Environmental Systems, 14th, San Diego, CA, July 16-19, 1984. 7 p. refs
(SAE PAPER 840978)

In recent years, with the advent of large spacecraft, thermal balance testing techniques using infrared lamp sources have

become increasingly attractive. In addition to cost savings, the IR technique is more versatile in terms of spacecraft orientation and supplied flux conditions. Because of the differences between solar illumination and IR simulation the IR lamp flux characteristics must be accurately determined. An equation predicting the incident flux distribution of a lamp reflector combination is developed for a Research Inc. lamp model 5236-5. The radiation absorbed by spacecraft surfaces under test conditions can be obtained from a computer code incorporating lamp arrays, specular baffles and surface property variations with lamp power level and radiation angle of incidence. Author

A85-34293
THE RADIATION SITUATION IN SPACE AND ITS MODIFICATION BY GEOMAGNETIC FIELD AND SHIELDING
W. HEINRICH and J. BEER (Sieger, Universitaet-Gesamthochschule, Siegen, West Germany) (COSPAR, Topical Meeting on Life Sciences and Space Research XXI(1), Graz, Austria, June 25-July 7, 1984) Advances in Space Research (ISSN 0273-1177), vol. 4, no. 10, 1984, p. 133-142. Sponsorship: Bundesministerium fuer Forschung und Technologie. refs
(Contract BMFT-01-QV-3127; BMFT-01-QV-2032; BMFT-01-QV-3029; BMFT-01-QV-2130)

The fluxes of the nuclear component of the galactic cosmic radiation are discussed in terms of energy spectra for the different elements. Influences of shielding by the earth's magnetic field on these spectra are described. Energy spectra behind the absorbing matter are calculated considering energy loss and fragmentation. Based on the energy spectra, LET-spectra are calculated. The form of the LET-spectra and their dependence on the composition of the shielding material are discussed. For LET-spectra measured by different detectors, the restricted energy losses are converted to LET (infinity) in water. After this it is possible to compare the results of different experiments with each other and with calculated LET-spectra. Author

A85-34295* San Francisco Univ., Calif.
SUMMARY OF CURRENT RADIATION DOSIMETRY RESULTS ON MANNED SPACECRAFT
E. V. BENTON (San Francisco, University, San Francisco, CA) (COSPAR, Topical Meeting on Life Sciences and Space Research XXI(1), Graz, Austria, June 25-July 7, 1984) Advances in Space Research (ISSN 0273-1177), vol. 4, no. 10, 1984, p. 153-160. refs
(Contract NAS9-15152)

It is pointed out that the experimental data existing on radiation levels inside orbiting spacecraft are currently limited. However, it is recognized that perhaps the single most important constraint to long-term manned space activity may be related to the complex space radiation environment. For this reason, it is important to know the radiological parameters which determine the biological effects of space radiation on humans. Attention is given to radiation dose measurements, LET (linear energy transfer) spectra for HZE particles, and dosimetry data from U.S. manned spaceflights. In particular, data are now available on dose rates in spacecraft at low altitudes (less than 300 km), while insufficient measurements exist for high altitude and high inclination orbits, geostationary orbits, and many orbits in between. Very little data exist on neutron dose and spectra. G.R.

A85-34296
THE MONITORING AND PREDICTION OF SOLAR PARTICLE EVENTS - AN EXPERIENCE REPORT
G. HECKMAN, J. HIRMAN, J. KUNCHES, and C. BALCH (NOAA, Space Environment Services Center, Boulder, CO) (COSPAR, Topical Meeting on Life Sciences and Space Research XXI(1), Graz, Austria, June 25-July 7, 1984) Advances in Space Research (ISSN 0273-1177), vol. 4, no. 10, 1984, p. 165-172.

The routine monitoring and prediction of solar proton events that may be a hazard to personnel and materials in space are a routine service of the Space Environment Services Center in Boulder, Colorado, U.S.A. The services provided are made available to the space centers in the United States for use in their operations. The real time monitoring consists primarily of Space Environment Monitors on both geosynchronous and polar orbiting weather satellites. The monitoring emphasizes proton fluxes but alpha particles, electrons, and in one case, heavier particles, are included. The predictions are of two types; a general outlook made 1 to 3 days in advance, and specific prediction of event size and probability of occurrence made after a solar flare occurs. The accuracy of the predictions made for solar cycle 21 are assessed. Author

A85-35158#
REACTION OF ATOMIC OXYGEN WITH VITREOUS CARBON - LABORATORY AND STS-5 DATA COMPARISONS
G. S. ARNOLD and D. R. PEPLINSKI (Aerospace Corp., Chemistry and Physics Laboratory, El Segundo, CA) AIAA Journal (ISSN 0001-1452), vol. 23, June 1985, p. 976, 977. Research supported by the Aerospace Corp. Previously cited in issue 06, p. 741, Accession no. A84-18159. refs

A85-35376#
DYNAMICS OF MAGNETOSPHERIC PLASMAS
J. L. HORWITZ (Alabama, University, Huntsville, AL) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 22, May-June 1985, p. 225-230. refs

The dynamical behavior of the magnetospheric plasmas which control the electrostatic charging of spacecraft is the result of the complex interaction of a variety of production, loss, transport, and energization mechanisms in the magnetosphere. This paper is intended to provide the spacecraft engineer with a foundation in the basic morphology and controlling processes pertaining to magnetospheric plasma dynamics in the inner magnetosphere, including the synchronous orbit region. Author

A85-35378#
CHARGING OF LARGE STRUCTURES IN SPACE WITH APPLICATION TO THE SOLAR SAIL SPACECRAFT
J. R. HILL and E. C. WHIPPLE, JR. (California, University, La Jolla, CA) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 22, May-June 1985, p. 245-253. Research supported by the University of California. refs

Some important charging effects at low altitudes are discussed, taking into account the charging of a spacecraft in the ionosphere. The possibility of large potentials in the polar ionosphere is considered along with the wake effect, and the electron collection for large positive potentials. The obtained information provides a basis for an investigation regarding the charging of a solar sail in earth orbit. This investigation is related to an experiment with a solar sail spacecraft which is being designed and built for launch into earth orbit in the near future. The general objective of the experiment is to evaluate solar sailing technology and to gain experience in the design and operation of a solar sail vehicle. Attention is given to the geometry of the solar sail, a model of the environment, plasma currents to the sail, secondary and photoemission currents to the sail, and equilibrium sail potentials. G.R.

A85-35379*# Alabama Univ., Huntsville.
EXPERIMENTS IN CHARGE CONTROL AT GEOSYNCHRONOUS ORBIT - ATS-5 AND ATS-6
R. C. OLSEN (Alabama, University, Huntsville, AL) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 22, May-June 1985, p. 254-264. refs
(Contract NSG-3150; NAS5-23481; NAS8-33982)

In connection with existing theoretical concepts, it was difficult to explain the negative potentials found in sunlight, first on Applied Technology Satellite-5 (ATS-5) and then on ATS-6. The problem became important when an association between spacecraft charging and anomalies in spacecraft behavior was observed. A study of daylight charging phenomena on ATS-6 was conducted, and an investigation was performed with the objective to determine effective methods of charge control, taking into account the feasibility to utilize the ATS-5 and ATS-6 ion engines as current

sources. In the present paper, data and analysis for the ion engine experiments on ATS-5 and ATS-6 are presented. It is shown that electron emission from a satellite with insulating surfaces is not an effective method of charge control because the increase in differential charging which results limits the effectiveness of electron emitters and increases the possibility of electrostatic discharges between surfaces at different potentials. G.R.

A85-36549* Lockheed Missiles and Space Co., Palo Alto, Calif.
THE IONOSPHERIC CONTRIBUTION TO THE PLASMA ENVIRONMENT IN NEAR-EARTH SPACE
R. D. SHARP, W. LENNARTSSON (Lockheed Research Laboratories, Palo Alto, CA), and R. J. STRANGEWAY (California, University, Los Angeles, CA) (U.S. Navy, U.S. Air Force, and U.S. Army, Symposium on the Effects of the Ionosphere on C3I /Command, Control, Communications and Intelligence/ Systems, Alexandria, VA, May 1-3, 1984) Radio Science (ISSN 0048-6604), vol. 20, May-June 1985, p. 456-462. Research supported by the Lockheed Independent Research Program. refs
(Contract N00014-78-C-0479; NASW-3395; NAS5-25773)

SCATHA and ISEE 1 satellite ion mass spectrometer data on ion composition near GEO are reviewed. The data were gathered during and close to magnetic storm activity to assess the characteristics of ion composition variations in order to predict the effects of hot GEO plasma on spacecraft instruments. Attention is given to both substorms and storms, the former being associated, at high latitudes, with auroral activity, the latter with ring currents. The ionosphere was found to supply hot H(+), O(+) and He(+) ions to the GEO magnetosphere, while the solar wind carried H(+) and He(+) ions. The ionosphere was the dominant source in both quiet and storm conditions in the inner magnetosphere. M.S.K.

A85-37614#
EFFECTS OF A SIMULATED SYNCHRONOUS ALTITUDE ENVIRONMENT ON CONTAMINATED OPTICAL SOLAR REFLECTORS
J. A. NEFF, C. R. MULLEN, and L. B. FOGDALL (Boeing Aerospace Co., Seattle, WA) American Institute of Aeronautics and Astronautics, Thermophysics Conference, 20th, Williamsburg, VA, June 19-21, 1985. 7 p.
(AIAA PAPER 85-0954)

Measurements have been made of the effects of a simulated synchronous attitude radiation environment on the solar absorptance of optical solar reflectors (OSR) contaminated with solid propellant volatile condensible material (VCM). Samples were simultaneously irradiated with 30 keV protons, 40 keV electrons and one equivalent sun ultraviolet (UV) radiation (200-400 nm) for a total of 245 hours in a 1 x 10 to the -7th torr vacuum. A flux of 5 x 10 to the 9th particles/sq cm-sec of both electrons and protons produced a total fluence of 5 x 10 to the 15th particles/sq cm of each type of particle by the end of the 245 hour test period. In a separate test, OSR samples contaminated with identical propellant VCM deposits were exposed to a UV-only environment for 245 hours. The results from the two tests showed a larger increase in solar absorptance with combined radiation (protons, electrons and UV) than with UV radiation alone. Author

A85-39976* Max-Planck-Inst. fuer Kernphysik, Heidelberg (West Germany).
SPACE DEBRIS, ASTEROIDS AND SATELLITE ORBITS; PROCEEDINGS OF THE FOURTH AND THIRTEENTH WORKSHOPS, GRAZ, AUSTRIA, JUNE 25-JULY 7, 1984
D. J. KESSLER (NASA, Johnson Space Center, Houston, TX), E. GRUEN (Max-Planck-Institut fuer Kernphysik, Heidelberg, West Germany), and L. SEHNAL (Astronomicka Observator, Ondrejov, Czechoslovakia) Workshops sponsored by COSPAR. Advances in Space Research (ISSN 0273-1177), vol. 5, no. 2, 1985, 235 p. For individual items see A85-39977 to A85-40003.

The workshops covered a variety of topics relevant to the identification, characterization and monitoring of near-earth solar system debris. Attention was given to man-made and naturally occurring microparticles, their hazards to present and future spacecraft, and ground- and space-based techniques for tracking both large and small debris. The studies are extended to solid fuel particulates in circular space. Asteroid rendezvous missions are discussed, including propulsion and instrumentation options, the possibility of encountering asteroids during Hohman transfer flights to Venus and/or Mars, and the benefits of multiple encounters by one spacecraft. Finally, equipment and analytical models for generating precise satellite orbits are reviewed. M.S.K.

A85-39985* Flow Research, Inc., Kent, Wash.
THE EFFECTS OF PARTICULATES FROM SOLID ROCKET MOTORS FIRED IN SPACE
A. C. MUELLER (Flow Industries, Inc., Kent, WA) and D. J. KESSLER (NASA, Johnson Space Center, Houston, TX) (COSPAR, Workshops on Space Debris, Asteroids and Satellite Orbits, 4th and 13th, Graz, Austria, June 25-July 7, 1984) Advances in Space Research (ISSN 0273-1177), vol. 5, no. 2, 1985, p. 77-86. refs

The orbits attained by kick motor solid propellant particulates are modeled, and an estimate is made of the number of particulates which will remain in orbit. The fuel, Al2O3, is burned while inserting spacecraft into a transfer orbit and again while circularizing the GEO station. It is shown that 23 percent of 1 micron particles deorbit immediately, while most particles enter a retrograde orbit. The resulting flux is an order of magnitude larger than the micrometeoroid flux. The pressures exerted by solar radiation ensure that only 5 percent of the original flux is still in orbit after the first year. The estimates provided are valid for a large number of transfer orbit operations, but will vary widely over the short term. M.S.K.

A85-41450
POTENTIAL EFFECTS OF COSMIC DUST AND ROCKET EXHAUST PARTICLES ON SPACECRAFT CHARGING
G. J. CORSO (Indiana University Northwest, Gary) Acta Astronautica (ISSN 0094-5765), vol. 12, April 1985, p. 265-267. refs

Attention is called to the importance of including the roles of cosmic dust particles and rocket exhaust particles in the detailed analysis of spacecraft charging effects, arcing and power drains due to leakage currents. Aspects of the problem pertaining to both low and high (geosynchronous) earth orbit are discussed. Recommendations are made to assessing the long-term effects of hypervelocity impacts of these particles. Author

A85-45416
ENVIRONMENTAL PLASMA INTERACTION CONSIDERATIONS IN SPACECRAFT POWER SOURCE DESIGN
G. T. INOUYE and K. J. DEGRAFFENREID (TRW, Inc., TRW Space and Technology Group, Redondo Beach, CA) IN: IECEC '84: Advanced energy systems - Their role in our future; Proceedings of the Nineteenth Intersociety Energy Conversion Engineering Conference, San Francisco, CA, August 19-24, 1984. Volume 1 . La Grange Park, IL, American Nuclear Society, 1984, p. 491-494. refs

Research is being conducted to determine the effect of environmental plasma on spacecraft systems. Power sources with voltages greater than 100 to 200 volts begin to be affected by plasma power loss. The plasma causes corona or arc breakdown, which results in the generation of electromagnetic interference (EMI), leading to problems in the operation of the spacecraft systems. Plasma power loss is caused by the electron emission effect, the pinhole effect, and the ram-wake effect. Since these mechanisms are electron oriented, the LEO environment, which has high electron density, is being closely studied. Laboratory tests and on-board testing have resulted in designs which counter plasma loss. Conductive coating applied to the backsides of solar arrays and dielectric surface coating prevents arc discharges. Also the standard procedure of grounding metallized thermal blanket layers counters plasma power loss. I.F.

A85-45428* National Aeronautics and Space Administration, Washington, D.C.
REVIEW OF THE TRI-AGENCY SPACE NUCLEAR REACTOR POWER SYSTEM TECHNOLOGY PROGRAM
J. H. AMBRUS (NASA, Washington, DC), W. E. WRIGHT (DARPA, Arlington, VA), and D. F. BUNCH (DOE, Washington, DC) IN: IECEC '84: Advanced energy systems - Their role in our future; Proceedings of the Nineteenth Intersociety Energy Conversion Engineering Conference, San Francisco, CA, August 19-24, 1984. Volume 1 . La Grange Park, IL, American Nuclear Society, 1984, p. 561-569.

The Space Nuclear Reactor Power System Technology Program designated SP-100 was created in 1983 by NASA, the U.S. Department of Defense, and the Defense Advanced Research Projects Agency. Attention is presently given to the development history of SP-100 over the course of its first year, in which it has been engaged in program objectives' definition, the analysis of civil and military missions, nuclear power system functional requirements' definition, concept definition studies, the selection of primary concepts for technology feasibility validation, and the acquisition of initial experimental and analytical results. O.C.

A85-45434
LONG LIFE AND LOW WEIGHT NI/CD CELLS FOR SPACECRAFT
H. S. LIM, S. A. VERZWYVELT, D. F. PICKETT, J. D. MARGERUM, R. C. KNECHTLI (Hughes Research Laboratories, Malibu, CA) et al. IN: IECEC '84: Advanced energy systems - Their role in our future; Proceedings of the Nineteenth Intersociety Energy Conversion Engineering Conference, San Francisco, CA, August 19-24, 1984. Volume 1 . La Grange Park, IL, American Nuclear Society, 1984, p. 609-614.

Nickel-cadmium cells of various designs, containing polymer reinforced inorganic separators and either chemically deposited or electrochemically deposited nickel and cadmium electrodes, have been studied for their cycle life performance. The performance goal of these Ni/Cd cells is more than 10 years of cycle life at 80 percent depth of discharge operation in a geosynchronous orbit. Three alternate cycle regimes, including one with a high rate (0.4C) charging (HGEO regime), were used to test the cells. In all cycle regimes, the performance goal appears to be feasible with selected cell designs. The cycle life, in general, was longer in the HGEO cycling regime. However, in practice this HGEO cycling requires a sequential charging system which results in a tradeoff to a standard low rate charge for GEO cycling because of the extra charge control equipment needed for an HGEO regime. Author

N85-22464*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
REPORT ON FINAL RECOMMENDATIONS FOR IMPS ENGINEERING-SCIENCE PAYLOAD
H. B. GARRETT 1 Sep. 1984 124 p refs
(Contract NAS7-918)
(NASA-CR-175659; JPL-PUB-84-56; NAS 1.26:175659) Avail: NTIS HC A06/MF A01 CSCL 22B

Six general categories of key scientific and engineering concerns for the interactions measurements payload for shuttle (IMPS) mission are addressed: (1) dielectric charging; (2) material property changes; (3) electromagnetic interference, plasma interactions, and plasma wake effects associated with high-voltage solar arrays and large space structures; (4) radio frequency distortion and nonlinearities due to the enhanced plasma in the shuttle ram/wake; (5) shuttle glow and contamination; and (6) plasma interactions with the space-based radar. Lesser concerns are the interactions associated with EVA; the radiation and SEU effects peculiar to the auroral/polar cap environments; and space debris. The measurements needed to address the concerns associated with the general categories are described and a list of generic investigations capable of making the required measurements, emphasizing the spectrum of measurements necessary to quantize the interactions in the auroral/polar environments are included. A suggested ground-test plan for the IMPS project, a description of proposed follow-on IMPS missions, and a detailed bibliography for each of the interactions discussed are included. Author

N85-22470*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
SPACECRAFT ENVIRONMENTAL INTERACTIONS TECHNOLOGY, 1983
Washington Mar. 1985 673 p refs Conf. held in Colorado Springs, 4-6 Oct. 1983 Prepared in cooperation with AFGL, Hanscom AFB, Mass.
(NASA-CP-2359; E-2186; NAS 1.55:2359; AFGL-TR-85-0018)
Avail: NTIS HC A99/MF E03 CSCL 22B

State of the art of environment interactions dealing with low-Earth-orbit plasmas; high-voltage systems; spacecraft charging; materials effects; and direction of future programs are contained in over 50 papers.

N85-22476*# Air Force Geophysics Lab., Hanscom AFB, Mass.
MEASURED ELECTRON CONTRIBUTION TO SHUTTLE PLASMA ENVIRONMENT: ABBREVIATED UPDATE
W. MCMAHON, R. SALTER, R. HILLS (Tri-Con Associates, Inc., Cambridge, Mass.), and D. DELOREY (Boston Coll., Chestnut Hill, Mass.) *In* NASA. Lewis Research Center Spacecraft Environ. Interactions Technol., 1983 p 71-80 Mar. 1985 refs
Avail: NTIS HC A99/MF E03 CSCL 22B

The differential energy spectra of electrons between 1 and 100 eV were measured by an electron spectrometer flown on an early shuttle. This energy range was scanned in 64 incremental steps with a resolution of 7%. The most striking feature that was observed throughout these spectra was a relatively flat distribution of the higher energy electrons out to 100 eV. This is in contrast to normal ambient spectra which consistently show a rapid decline in quantitative flux beyond 50 to 55 eV. The lower energy (1 to 2 eV) end of these spectra showed steep thermal trails comparable to normal ambient spectral structure. In general, daytime fluxes were significantly higher than those obtained during nighttime measurements. Quantitative flux excursions which may possibly be associated with thruster firing were frequently observed. Spectral structure suggestive of the N2 vibrational excitation energy loss mechanism was also seen in the data from some measurement periods. Examples of these spectra are shown and possible correlations are discussed. Author

N85-22479*# Michigan Univ., Ann Arbor.
SPACECRAFT-ENVIRONMENT INTERACTION: THE ENVIRONMENTAL PLASMA ASPECT
U. SAMIR *In* NASA. Lewis Research Center Spacecraft Environ. Interactions Technol., 1983 p 103-107 Mar. 1985 refs
Avail: NTIS HC A99/MF E03 CSCL 22B

The effects involved in the interaction between an obstacle and a space plasma can be divided into: (1) effects on the obstacle itselt (i.e., its charging); and (2) effects on the environmental plasma due to the motion of the obstacle (i.e., the creation of shocks ahead of the obstacle and complicated wakes behind the obstacle). In the wake (or antisolar direction), plasma oscillations are excited and instabilities, wave-particle interactions, turbulence, etc., are believed to take place. The effects on the obstacle and on the environmental space plasma are coupled. Hence, simultaneous solutions to the Vlasov (or Boltzmann) and Poisson equations are sought. To obtain realistic solutions of practical use, three-dimensional and time-dependent models of the interaction are needed. Achieving the latter is indeed not simple. G.L.C.

N85-22480*# Air Force Geophysics Lab., Hanscom AFB, Mass.
DIRECT MEASUREMENTS OF SEVERE SPACECRAFT CHARGING IN AURORAL IONOSPHERE
W. J. BURKE, D. A. HARDY, F. J. RICH, A. G. RUBIN, M. F. TAUTZ (RADEX, Inc.), N. A. SAFLEKOS (Boston Coll., Chestnut Hill, Mass.), and H. C. YEH (Boston Coll., Chestnut Hill, Mass.) *In* NASA. Lewis Research Center Spacecraft Environ. Interactions Technol., 1983 p 109-123 Mar. 1985 refs
Avail: NTIS HC A99/MF E03 CSCL 22B

Questions are addressed concerning how large space structures in polar orbit will interact with auroral environments. Because spacecraft charging at ionospheric attitudes does not seriously threaten the operation of today's relatively small polar satellites the subject of environment interactions has not received the widespread attention given to it at geostationary altitude. As a matter of economics it is desirable to apply as much as possible of what was learned about spacecraft interactions at geostationary orbit to low Earth orbits. The environment at auroral latitudes in the ionosphere differs from that encountered at geostationary altitude in at least two major aspects. (1) There is a large reservoir of high-density, cold plasma which tends to mitigate charging effects by providing a large source of charged particles from which neutralizing currents maybe drawn. Significant wake effects behind large structures will introduce new problems with differential charging. (2) Between the magnetic equator and the ionosphere, auroral electrons frequently undergo field-aligned accelerations of several kilovolts. In such environments, fluxes of energetic protons are usually below the levels of instrumentation sensitivity. G.L.C.

N85-22482*# Air Force Geophysics Lab., Hanscom AFB, Mass.
AVERAGE AND WORST-CASE SPECIFICATIONS OF PRECIPITATING AURORAL ELECTRON ENVIRONMENT
D. A. HARDY, W. J. BURKE, M. S. GUSSENHOVEN, E. HOLEMAN (Emmanuel Coll.), and H. C. YEH (Boston Coll., Chestnut Hill, Mass.) *In* NASA. Lewis Research Center Spacecraft Environ. Interactions Technol., 1983 p 131-153 Mar. 1985 refs
Avail: NTIS HC A99/MF E03 CSCL 22B

The precipitation electrons in the auroral environment are highly variable in their energy and intensity in both space and time. As such they are a source of potential hazard to the operation of the Space Shuttle and other large spacecraft operating in polar orbit. In order to assess these hazards both the average and extreme states of the precipitating electrons must be determined. Work aimed at such a specification is presented. First results of a global study of the average characteristics are presented. In this study the high latitude region was divided into spatial elements in magnetic local time and corrected geomagnetic latitude. The average electron spectrum was then determined in each spatial element for seven different levels of activity as measured by K sub p using an extremely large data set of auroral observations. Second a case study of an extreme auroral electron environment is presented, in which the electrons are accelerated through field aligned potential as high as 30,000 volts and in which the spacecraft is seen to charge negatively to a potential approaching .5 kilovolts. G.L.C.

N85-22484*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
AURORAL-POLAR CAP ENVIRONMENT AND ITS IMPACT ON SPACECRAFT PLASMA INTERACTIONS
H. B. GARRETT *In* NASA. Lewis Research Center Spacecraft Environ. Interactions Technol., 1983 p 177-193 Mar. 1985 refs Sponsored in part by AFGL
(Contract NAS7-918)
Avail: NTIS HC A99/MF E03 CSCL 22B

The high density of the plasma at shuttle altitude is likely to increase greatly the possibility of arcing and shorting of exposed high voltage surfaces. For military missions over the polar caps and through the auoroal zones, the added hazards of high energy auroral particle fluxes or solar flares will further increase the hazard to shuttle, its crew, and its mission. A review of the role that the auroral and polar cap environment play in causing these interactions was conducted. A simple, though comprehensive attempt at modelling the shuttle environment at 400 km will be described that can be used to evaluate the importance of the interactions. The results of this evaluation are then used to define areas where adequate environmental measurements will be necessary if a true spacecraft interactions technology is to be developed for the shuttle. G.L.C.

N85-22485*# Systems Science and Software, La Jolla, Calif.
ELECTRIC FIELD EFFECTS ON ION CURRENTS IN SATELLITE WAKES
D. E. PARKS and I. KATZ *In* NASA. Lewis Research Center Spacecraft Environ. Interactions Technol., 1983 p 195-204 Mar. 1985 refs
(Contract F19628-82-C-0081)
Avail: NTIS HC A99/MF E03 CSCL 22B

Small currents associated with satellite spin, dielectric conduction, or trace concentrations of H+, can have a substantial effect on the potential of a satellite and the particle currents reaching its surface. The importance of such small currents at altitudes below about 300 km stems from the extremely small 0+ currents impinging on the wake-side of the spacecraft. The particle current on the downstream side of the AE-C satellite is considered. Theoretical estimates based on a newly described constant of the motion of a particle indicate that accounting for small concentrations of H+ remove a major discrepancy between calculated and measured currents. G.L.C.

N85-22486*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
THREE-DIMENSIONAL CALCULATION OF SHUTTLE CHARGING IN POLAR ORBIT
D. L. COOKE, I. KATZ, M. J. MANDELL, J. R. LILLEY, JR., and A. J. RUBIN (AFGL) *In* NASA. Lewis Research Center Spacecraft Environ. Interactions Technol., 1983 p 205-227 Mar. 1985 refs
(Contract F19628-82-C-0081)
Avail: NTIS HC A99/MF E03 CSCL 22B

The charged particles environment in polar orbit can be of sufficient intensity to cause spacecraft charging. In order to gain a quantitative understanding of such effects, the Air Force is developing POLAR, a computer code which simulates in three dimensions the electrical interaction of large space vehicles with the polar ionospheric plasma. It models the physical processes of wake generation, ambient ion collection, precipitating auroral electron fluxes, and surface interactions, including secondary electron generation and backscattering, which lead to vehicle charging. These processes may be followed dynamically on a subsecond timescale so that the rapid passage through intense auroral arcs can be simulated. POLAR models the ambient plasma as isotropic Maxwellian electrons and ions (0+, H+), and allows for simultaneous precipitation of power-law, energetic Maxwellian, and accelerated Gaussian distributions of electrons. Magnetic field effects will be modeled in POLAR but are currently ignored.
G.L.C.

N85-22487*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
POLAR ORBIT ELECTROSTATIC CHARGING OF OBJECTS IN SHUTTLE WAKE
I. KATZ, D. E. PARKS, D. L. COOKE, M. J. MANDELL (AFGL), and A. J. RUBIN *In* NASA. Lewis Research Center Spacecraft Environ. Interactions Technol., 1983 p 229-234 Mar. 1985 refs
(Contract F19628-82-C-0081)
Avail: NTIS HC A99/MF E03 CSCL 22B

A survey of DMSP data has uncovered several cases where precipitating auroral electron fluxes are both sufficiently intense and energetic to charge spacecraft materials such as teflon to very large potentials in the absence of ambient ion currents. Analytical bounds are provided which show that these measured environments can cause surface potentials in excess of several hundred volts to develop on objects in the orbiter wake for particular vehicle orientations. G.L.C.

N85-22488*# Parker (Lee W.), Inc., Concord, Mass.
WAKES AND DIFFERENTIAL CHARGING OF LARGE BODIES IN LOW EARTH ORBIT
L. W. PARKER *In* NASA. Lewis Research Center Spacecraft Environ. Interactions Technol., 1983 p 235-252 Mar. 1985 refs
Avail: NTIS HC A99/MF E03 CSCL 22B

Highlights of earlier results using the Inside-Out WAKE code on wake structures of LEO spacecraft are reviewed. For conducting bodies of radius large compared with the Debye length, a high Mach number wake develops a negative potential well. Quasineutrality is violated in the very near wake region, and the wake is relatively empty for a distance downstream of about one half of a Mach number of radii. There is also a suggestion of a core of high density along the axis. A comparison of rigorous numerical solutions with in situ wake data from the AE-C satellite suggests that the so called neutral approximation for ions (straight line trajectories, independent of fields) may be a reasonable approximation except near the center of the near wake. This approximation is adopted for very large bodies. Work concerned with the wake point potential of very large nonconducting bodies such as the shuttle orbiter is described. Using a cylindrical model for bodies of this size or larger in LEO (body radius up to 10 to the 5th power Debye lengths), approximate solutions are presented based on the neutral approximation (but with rigorous trajectory calculations for surface current balance). There is a negative potential well if the body is conducting, and no well if the body is nonconducting. In the latter case the wake surface itself becomes highly negative. The wake point potential is governed by the ion drift energy. M.G.

N85-22489*# Air Force Geophysics Lab., Hanscom AFB, Mass.
SHEATH IONIZATION MODEL OF BEAM EMISSIONS FROM LARGE SPACECRAFT
S. T. LAI, H. A. COHEN, K. H. BHAVNANI (RADEX, Inc.), and M. E. TAUTZ (RADEX, Inc.) *In* NASA. Lewis Research Center Spacecraft Environ. Interactions Technol., 1983 p 253-262 Mar. 1985 refs Previously announced as N84-19463
Avail: NTIS HC A99/MF E03 CSCL 22B

An analytical model of the charging of a spacecraft emitting electron and ion beams has been applied to the case of large spacecraft. In this model, ionization occurs in the sheath due to the return current. Charge neutralization of spherical space charge flow is examined by solving analytical equations numerically. Parametric studies of potential large spacecraft are performed. As in the case of small spacecraft, the ions created in the sheath by the returning current play a large role in determining spacecraft potential. Author (GRA)

N85-22490*# Hughes Aircraft Co., El Segundo, Calif.
INTERACTIONS BETWEEN LARGE SPACE POWER SYSTEMS AND LOW-EARTH-ORBIT PLASMAS
N. J. STEVENS *In* NASA. Lewis Research Center Spacecraft Environ. Interactions Technol., 1983 p 263-276 Mar. 1985 refs
Avail: NTIS HC A99/MF E03 CSCL 22B

There is a growing tendency to plan space missions that will incorporate very large space power systems. These space power systems must function in the space plasma environment, which can impose operational limitations. As the power output increases, the operating voltage also must increase and this voltage, exposed at solar array interconnects, interacts with the local plasma. The implications of such interactions are considered. The available laboratory data for biased array segment tests are reviewed to demonstrate the basic interactions considered. A data set for a floating high voltage array test was used to generate approximate relationships for positive and negative current collection from plasmas. These relationships were applied to a hypothetical 100 kW power system operating in a 400 km, near equatorial orbit. It was found that discharges from the negative regions of the array are the most probable limiting factor in array operation. Author

N85-22491*# York Univ., Toronto (Ontario).
CALCULATION OF SECONDARY-ELECTRON ESCAPE CURRENTS FROM INCLINED-SPACECRAFT SURFACES IN A MAGNETIC FIELD
J. G. LAFRAMBOISE *In* NASA. Lewis Research Center Spacecraft Environ. Interactions Technol., 1983 p 277-286 Mar. 1985 refs
(Contract F19628-83-K-0028)
Avail: NTIS HC A99/MF E03 CSCL 22B

In low Earth orbit, the geomagnetic field B(vector) is strong enough that secondary electrons emitted from spacecraft surfaces have an average gyroradius much smaller than typical dimensions of large spacecraft. This implies that escape of secondaries will be strongly inhibited on surfaces which are nearly parallel to B(vector), even if a repelling electric field exists outside them. This effect is likely to make an important contribution to the current balance and hence the equilibrium potential of such surfaces, making high voltage charging of them more likely. Numerically calculated escaping secondary electron fluxes are presented for these conditions. For use in numerical spacecraft charging simulations, an analytic curve fit to these results is given which is accurate to within 3% of the emitted current. M.G.

N85-22492*# Kansas Univ., Lawrence.
SELF-CONSISTENT SIMULATION OF PLASMA INTERACTIONS WITH SECONDARY-EMITTING INSULATORS
S. T. BRANDON, R. L. RUSK, T. P. ARMSTRONG, and J. ENOCH *In* NASA. Lewis Research Center Spacecraft Environ. Interactions Technol., 1983 p 287-303 Mar. 1985 refs
Avail: NTIS HC A99/MF E03 CSCL 20I

A cylindrical particle-in-cell (PIC) plasma simulation code applicable to plasma densities encountered in low Earth orbit (LEO) is described. The simulated geometries include that of a plain disk and a disk surrounded by a dielectric. Both configurations are mounted upon a ground plate in contact with a plasma environment. Techniques allowing simulation of dielectric charging using PIC time scales are discussed. Current versus voltage characteristic curves are calculated and the results are compared to experimental data. M.G.

N85-22493*# Systems Science and Software, La Jolla, Calif.
SURFACE INTERACTIONS AND HIGH-VOLTAGE CURRENT COLLECTION
M. J. MANDELL and I. KATZ *In* NASA. Lewis Research Center Spacecraft Environ. Interactions Technol., 1983 p 305-320 Mar. 1985 refs
(Contract NAS3-23058)
Avail: NTIS HC A99/MF E03 CSCL 22B

Spacecraft of the future will be larger and have higher power requirements than any flown to date. For several reasons, it is desirable to operate a high power system at high voltage. While the optimal voltages for many future missions are in the range 500 to 5000 volts, the highest voltage yet flown is approximately 100 volts. The NASCAP/LEO code is being developed to embody the phenomenology needed to model the environmental interactions of high voltage spacecraft. Some plasma environment are discussed. The treatment of the surface conductivity associated with emitted electrons and some simulations by NASCAP/LEO of ground based high voltage interaction experiments are described. Author

N85-22494*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
THE PIX-2 EXPERIMENT: AN OVERVIEW
C. K. PURVIS *In its* Spacecraft Environ. Interactions Technol. p 321-332 Mar. 1985 refs
Avail: NTIS HC A99/MF E03 CSCL 20I

The second Plasma Interactions Experiment (PIX-2) was launched in January 1983 as a piggyback on the second stage of the Delta launch vehicle that carried IRAS into orbit. Placed in a 870 km circular polar orbit, it returned 18 hrs of data on the plasma current collection and arcing behavior of solar arrays biased to +/-1000 V in steps. The four 500 sq cm solar array segments

were biased singly and in combinations. In addition to the array segments PIX-2 carried a Sun sensor, a Langmuir probe to measure electron currents, and a hot-wire filament electron emitter to control vehicle potential during positive array bias sequences. The PIX-2 experiment is reviewed from program and operational perspectives. M.G.

N85-22495*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
PLASMA INTERACTION EXPERIMENT 2 (PIX 2): LABORATORY AND FLIGHT RESULTS
N. T. GRIER *In its* Spacecraft Environ. Interactions Technol. p 333-347 Mar. 1985
Avail: NTIS HC A99/MF E03 CSCL 20I

The Plasma Interaction Experiments 1 and 2 (PIX 1 and 2) were designed as first steps toward understanding interactions between high-voltage solar arrays and the surrounding plasma. The PIX 2 consisted of an approximately 2000-sq cm array divided into four equal segments. Each of the segments could be biased independently and the current measured separately. In addition to the solar array segments, PIX 2 had a hot-wire-filament electron emitter and a spherical Langmuir probe. The emitter was operated when the array segments were biased positively bove 125 V. Thermal electrons from the emitter aided in balancing the electron currents collected by the array. Laboratory and flight results of PIX 2 are presented. At high positive voltages on the solar array segments, the flight currents were approximately an order of magnitude larger than the ground test currents. This is attributed to the tank walls in the laboratory interfering with the electron currents to the array segments. From previous tests it is known that the tank walls limit the electron currents at high voltages. This was the first verification of the extent of the laboratory tank effect on the plasma coupling current. M.G.

N85-22496*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
RAM-WAKE EFFECTS ON PLASMA CURRENT COLLECTION OF THE PIX 2 LANGMUIR PROBE
D. C. FERGUSON *In its* Spacecraft Environ. Interactions Technol. p 349-357 Mar. 1985 refs
Avail: NTIS HC A99/MF E03 CSCL 20I

The Plasma Interaction Experiment 2 (PIX 2) Langmuir probe readings of the same polar magnetospheric regions taken on consecutive orbits showed occasional apparent densities as much as 10 times lower than the average, although each pass clearly showed density structures related to the day/night boundary. At other points in the orbit, Langmuir probe currents varied by as much as a factor of 20 on a time scale of minutes. The hypothesis is advanced that these apparent inconsistencies in Langmuir probe current are the results of the probe's orientation relative to the body of the spacecraft and the velocity vector. Theoretical studies predict a possible depletion in collected electron current by a factor of 100 in the wake. Experimental results from other spacecraft indicate that a wake electron depletion by a factor of 10 or so is realistic. This amount of depletion is consistent with the PIX 2 data if the spacecraft was rotating. Both the Sun sensor and temperature sensor data on PIX 2 show a complex variation consistent with rotation of the Langmuir probe into and out of the spacecraft wake on a time scale of minutes. Furthermore, Langmuir probe data taken when the probe was not in the spacecraft wake are consistent from orbit to orbit. This supports the interpretation that ram/wake effects may be the source of apparent discrepancies at other orientations. M.G.

N85-22497*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
NASCAP SIMULATION OF PIX 2 EXPERIMENTS
J. C. ROCHE and M. J. MANDELL (Systems, Science and Software, San Diego) *In its* Spacecraft Environ. Interactions Technol. p 359-366 Mar. 1985
Avail: NTIS HC A99/MF E03 CSCL 20I

The latest version of the NASCAP/LEO digital computer code used to simulate the PIX 2 experiment is discussed. NASCAP is a finite-element code and previous versions were restricted to a single fixed mesh size. As a consequence the resolution was dictated by the largest physical dimension to be modeled. The latest version of NASCAP/LEO can subdivide selected regions. This permitted the modeling of the overall Delta launch vehicle in the primary computational grid at a coarse resolution, with subdivided regions at finer resolution being used to pick up the details of the experiment module configuration. Langmuir probe data from the flight were used to estimate the space plasma density and temperature and the Delta ground potential relative to the space plasma. This information is needed for input to NASCAP. Because of the uncertainty or variability in the values of these parameters, it was necessary to explore a range around the nominal value in order to determine the variation in current collection. The flight data from PIX 2 were also compared with the results of the NASCAP simulation. R.J.F.

N85-22499*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
DISCHARGES ON A NEGATIVELY BIASED SOLAR CELL ARRAY IN A CHARGED-PARTICLE ENVIRONMENT
D. B. SNYDER *In its* Spacecraft Environ. Interactions Technol. p 379-388 Mar. 1985 refs Previously announced as N84-23690
Avail: NTIS HC A99/MF E03 CSCL 10A

The charging behavior of a negatively biased solar cell array when subjected to a charged particle environment is studied in the ion density range from 200 to 12,000 ions/sq cm with the applied bias range of -500 to -1400 V. The profile of the surface potentials across the array is related to the presence of discharges. At the low end of the ion density range the solar cell cover slides charge to from 0 to +5 volts independent of the applied voltage. No discharges are seen at bias voltages as large as -1400 V. At the higher ion densities the cover slide potential begins to fluctuate, and becomes significantly negative. Under these conditions discharges can occur. The threshold bias voltage for discharges decreases with increasing ion density. A condition for discharges emerging from the experimental observations is that the average coverslide potential must be more negative than -4 V. The observations presented suggest that the plasma potential near the array becomes negative before a discharge occurs. This suggests that discharges are driven by an instability in the plasma. Author

N85-22500*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
DESIGN GUIDELINES FOR ASSESSING AND CONTROLLING SPACECRAFT CHARGING EFFECTS Abstract Only
C. K. PURVIS, H. B. GARRETT (JPL, California Inst. of Tech., Pasadena), A. WHITTLESEY (JPL, California Inst. of Tech., Pasadena), and N. J. STEVENS (Hughes Aircraft Co., El Segundo, Calif.) *In its* Spacecraft Environ. Interactions Technol. p 389 Mar. 1985 Previously announced as N84-33452
Avail: NTIS HC A99/MF E03 CSCL 22B

The need for uniform criteria, or guidelines, to be used in all phases of spacecraft design is discussed. Guidelines were developed for the control of absolute and differential charging of spacecraft surfaces by the lower energy space charged particle environment. Interior charging due to higher energy particles is not considered. A guide to good design practices for assessing and controlling charging effects is presented. Uniform design practices for all space vehicles are outlined. E.A.K.

N85-22501*# Aerospace Corp., Los Angeles, Calif.
AEROSPACE SPACECRAFT-CHARGING GUIDELINES DOCUMENT Abstract Only
J. F. FENNELL, D. F. HALL, H. C. KOONS, P. F. MIZERA, and A. F. VAMPOLA *In* NASA. Lewis Research Center Spacecraft Environ. Interactions Technol., 1983 p 391 Mar. 1985
Avail: NTIS HC A99/MF E03 CSCL 22B

A short summary document on spacecraft charging was prepared for use by engineers in the various Aerospace Corporation program offices that support Air Force Space Division programs.

The magnetospheric charging environment at near-geosynchronous altitudes is outlined and the mechanisms of charging and discharging are discussed. Statistical results from the P78-2 (SCATHA) satellite engineering experiments are given. The document is intended to be a layman's source for charging information and for design guidance and criteria. R.J.F.

N85-22502*# Boston Coll., Chestnut Hill, Mass.
EMI CHARACTERISTICS OF A POTENTIAL CONTROL SYSTEM
D. E. DONATELLI, H. A. COHEN (AFGL), W. J. BURKE (AFGL), and H. C. KOONS (Aerospace Corp., Los Angeles) *In* NASA. Lewis Research Center Spacecraft Environ. Interactions Technol., 1983 p 393-411 Mar. 1985 refs
(Contract F19628-81-K-0011)
Avail: NTIS HC A99/MF E03 CSCL 22B

With the development and use of charged particle sources for controlling spacecraft potentials there is a need to better understand the effects of these systems on spacecraft operations. The emission of charged particles perturbs the spacecraft environment and signals are generated which may interfere with other vehicle functions. In particular, the generated signals are apt to interfere with detectors for observing waves that exist naturally in the space environment. Examples of this type of interference are presented from the SCATHA satellite during a period when the vehicle was highly charged. A plasma source on board the spacecraft succeeded in discharging the vehicle with each of four different operating modes. The VLF broadband receiver on SCATHA detected interference over the entire 0-5 kHz range of both the electric and magnetic field detectors during these charged particle emissions. This frequency range includes the 2 kHz electron gyrofrequency but is below the 9 kHz electron plasma frequency. The observations suggest that interference occurs through introduction of anomalous signals, and through suppression of background field measurements. Author

N85-22503*# California Univ., San Diego, La Jolla.
ANOMALOUSLY HIGH POTENTIALS OBSERVED ON ISEE
E. C. WHIPPLE, I. S. KRINSKY, R. B. TORBERT, and R. C. OLSEN (Alabama Univ., Huntsville) *In* NASA. Lewis Research Center Spacecraft Environ. Interactions Technol., 1983 p 413-422 Mar. 1985 refs Previously announced as N84-17258
(Contract NAG-320)
Avail: NTIS HC A99/MF E03 CSCL 22B

Data from two electric field experiments and from the plasma composition experiment on ISEE-1 are used to show that the spacecraft charged to close to -70 V in sunlight at 0700 UT on March 17, 1978. Data from the electron spectrometer experiment show that there was a potential barrier of -10 to -20 V about the spacecraft during this event. The potential barrier was effective in turning back emitted photoelectrons to the spacecraft. The stringent electrostatic cleanliness specifications imposed on ISEE make the presence of differential charging unlikely. Modeling of this event is required to determine if the barrier was produced by the presence of space charge. Author (ESA)

N85-22504*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
GALILEO INTERNAL ELECTROSTATIC DISCHARGE PROGRAM
P. L. LEUNG, G. H. PLAMP, and P. A. ROBINSON, JR. *In* NASA. Lewis Research Center Spacecraft Environ. Interactions Technol., 1983 p 423-433 Mar. 1985 refs
Avail: NTIS HC A99/MF E03 CSCL 22B

The Galileo spacecraft which will orbit Jupiter in 1988 will encounter a very harsh environment of energetic electrons. These electrons will have sufficient energy to penetrate the spacecraft shielding, consequently depositing charges in the dielectric insulating materials or ungrounded conductors. The resulting electric field could exceed the breakdown strength of the insulating materials, producing discharges. The transients produced from these Internal Electrostatic Discharges (IESD) could, depending on their relative location, be coupled to nearby cables and circuits. These transients could change the state of logic circuits or degrade or even damage spacecraft components, consequently disrupting the operation of subsystems and systems of the Galileo spacecraft during its expected mission life. An extensive testing program was initiated for the purpose of understanding the potential threats associated with these IESD events. Data obtained from these tests were used to define design guidelines. Author

N85-22505*# TRW Space Technology Labs., Redondo Beach, Calif.
CHARACTERISTICS OF EMI GENERATED BY NEGATIVE METAL-POSITIVE DIELECTRIC VOLTAGE STRESSES DUE TO SPACECRAFT CHARGING
R. C. CHAKY and G. T. INOUYE *In* NASA. Lewis Research Center Spacecraft Environ. Interactions Technol., 1983 p 437-452 Mar. 1985 refs
Avail: NTIS HC A99/MF E03 CSCL 20N

Charging of spacecraft surfaces by the environmental plasma can result in differential potentials between metallic structure and adjacent dielectric surfaces in which the relative polarity of the voltage stress is either negative dielectric/positive metal or negative metal/positive dielectric. Negative metal/positive dielectric is a stress condition that may arise if relatively large areas of spacecraft surface metals are shadowed from solar UV and/or if the UV intensity is reduced as in the situation in which the spacecraft is entering into or leaving eclipse. The results of experimental studies of negative metal/positive dielectric systems are given. Information is given on: enhanced electron emission I-V curves; e(3) corona noise vs e(3) steady-state current; the localized nature of e(3) and negative metal arc discharge currents; negative metal arc discharges at stress thresholds below 1 kilovolt; negative metal arc discharge characteristics; dependence of blowoff arc discharge current on spacecraft capacitance to space (linear dimension); and damage to second surface mirrors due to negative metal arcs. R.J.F.

N85-22507*# SRI International Corp., Menlo Park, Calif.
DEVELOPMENT OF A CONTINUOUS BROAD-ENERGY-SPECTRUM ELECTRON SOURCE
R. C. ADAMO and J. E. NANEVICZ *In* NASA. Lewis Research Center Spacecraft Environ. Interactions Technol., 1983 p 465-475 Mar. 1985 refs
(Contract DNA001-81-C-0267)
Avail: NTIS HC A99/MF E03 CSCL 14B

The development of a practical prototype, large-area, continuous-spectrum, multienergy electron source to simulate the lower energy (approx = 1 to 30 keV) portion of the geosynchronous orbit electron environment was investigated. The results of future materials-charging tests using this multienergy source should significantly improve the understanding of actual in-orbit charging processes and should help to resolve some of the descrepancies between predicted and observed spacecraft materials performance. E.A.K.

N85-22508*# Air Force Geophysics Lab., Hanscom AFB, Mass.
AUTOMATIC CHARGE CONTROL SYSTEM FOR SATELLITES
B. M. SHUMAN and H. A. COHEN *In* NASA. Lewis Research Center Spacecraft Environ. Interactions Technol., 1983 p 477-481 Mar. 1985 refs
Avail: NTIS HC A99/MF E03 CSCL 22B

The SCATHA and the ATS-5 and 6 spacecraft provided insights to the problem of spacecraft charging at geosychronous altitudes. Reduction of the levels of both absolute and differential charging was indicated, by the emission of low energy neutral plasma. It is appropriate to complete the transition from experimental results to the development of a system that will sense the state-of-charge of a spacecraft, and, when a predetermined threshold is reached, will respond automatically to reduce it. A development program was initiated utilizing sensors comparable to the proton electrostatic analyzer, the surface potential monitor, and the transient pulse monitor that flew in SCATHA, and combine these outputs through a microprocessor controller to operate a rapid-start, low energy plasma source. E.A.K.

N85-22509*# *Rome Air Development Center, Hanscom AFB, Mass.*
DISCHARGE PULSE PHENOMENOLOGY
A. R. FREDERICKSON *In* NASA. Lewis Research Center Spacecraft Environ. Interactions Technol., 1983 p 483-509 Mar. 1985 refs
Avail: NTIS HC A99/MF E03 CSCL 20N

A model was developed which places radiation induced discharge pulse results into a unified conceptual framework. Only two phenomena are required to interpret all space and laboratory results: (1) radiation produces large electrostatic fields inside insulators via the trapping of a net space charge density; and (2) the electrostatic fields initiate discharge streamer plasmas similar to those investigated in high voltage electrical insulation materials; these streamer plasmas generate the pulsing phenomena. The apparent variability and diversity of results seen is an inherent feature of the plasma streamer mechanism acting in the electric fields which is created by irradiation of the dielectrics. The implications of the model are extensive and lead to constraints over what can be done about spacecraft pulsing. E.A.K.

N85-22510*# JAYCOR, San Diego, Calif.
DISCHARGE CHARACTERISTICS OF DIELECTRIC MATERIALS EXAMINED IN MONO-, DUAL-, AND SPECTRAL ENERGY ELECTRON CHARGING ENVIRONMENTS
P. COAKLEY, M. TREADWAY, N. WILD, and B. KITTERER *In* NASA. Lewis Research Center Spacecraft Environ. Interactions Technol., 1983 p 511-524 Mar. 1985 refs
(Contract F29601-82-C-0015)
Avail: NTIS HC A99/MF E03 CSCL 18H

The effects of midenergy electrons on the charge and discharge characteristics of spacecraft dielectric materials and the data base from which basic discharge models can be formulated is expanded. Thin dielectric materials were exposed to low, mid combined low and mid, and spectral energy electron environments. Three important results are presented: (1) it determined electron environments that lead to dielectric discharges at potentials less negative than -5 kV; (2) two types of discharges were identified that dominate the kinds of discharges seen; and (3) it is shown that, for the thin dielectric materials tested, the worst-case discharges observed in the various environments are similar.
E.A.K.

N85-22515*# Communications Satellite Corp., Clarksburg, Md. COMSAT Lab.
INVESTIGATIONS OF RADIATION-INDUCED AND CARRIER-ENHANCED CONDUCTIVITY
A. MEULENBERG, JR., L. W. PARKER (Parker (Lee W.), Inc., Concord, Mass.), E. J. YADLOWSKI (H-Y Tek Corp., Radford, Va.), and R. C. HAZELTON (H-Y Tek Corp., Radford, Va.) *In* NASA. Lewis Research Center Spacecraft Environ. Interactions Technol., 1983 p 571-590 Mar. 1985 refs
Avail: NTIS HC A99/MF E03 CSCL 09C

A steady-state carrier computer code, PECK (Parker Enhanced Carrier Kinetics), that predicts the radiation-induced conductivity (RIC) produced in a dielectric by an electron beam was developed. The model, which assumes instantly-trapped holes, was then applied to experimental measurements on thin Kapton samples penetrated by an electron beam. Measurements at high bias were matched in the model by an appropriate choice for the trap-modulated electron mobility. A fractional split between front and rear currents measured at zone bias is explained on the basis of beam-scattering. The effects of carrier-enhanced conductivity (CEC) on data obtained for thick, free-surface Kapton samples is described by using an analytical model that incorporates field injection of carriers from the RIC region. The computer code, LWPCHARGE, modified for carrier transport, is also used to predict partial penetration effects associated with CEC in the unirradiated region. Experimental currents and surface voltages, when incorporated in the appropriate models, provide a value for the trap modulated mobility that is in essential agreement with the RIC results. B.W.

N85-22516*# *Beers Associates, Inc., Reston, Va.*
A SIMPLE MODEL OF ELECTRON BEAM INITIATED DIELECTRIC BREAKDOWN
B. L. BEERS, R. E. DANIELL, and T. N. DELMER *In* NASA. Lewis Research Center Spacecraft Environ. Interactions Technol., 1983 p 591-598 Mar. 1985 refs
(Contract F19601-82-C-0023)
Avail: NTIS HC A99/MF E03 CSCL 20H

A steady state model that describes the internal charge distribution of a planar dielectric sample exposed to a uniform electron beam was developed. The model includes the effects of charge deposition and ionization of the beam, separate trap-modulated mobilities for electrons and holes, electron-hole recombination, and pair production by drifting thermal electrons. If the incident beam current is greater than a certain critical value (which depends on sample thickness as well as other sample properties), the steady state solution is non-physical. B.W.

N85-22517*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
SPACECRAFT ENVIRONMENTAL INTERACTIONS: A JOINT AIR FORCE AND NASA RESEARCH AND TECHNOLOGY PROGRAM
C. P. PIKE (AFGL), C. K. PURVIS, and W. R. HUDSON (NASA, Washington) *In its* Spacecraft Environ. Interactions Technol., 1983 p 599-608 Mar. 1985
Avail: NTIS HC A99/MF E03 CSCL 22B

A joint Air Force/NASA comprehensive research and technology program on spacecraft environmental interactions to develop technology to control interactions between large spacecraft systems and the charged-particle environment of space is described. This technology will support NASA/Department of Defense operations of the shuttle/IUS, shuttle/Centaur, and the force application and surveillance and detection missions, planning for transatmospheric vehicles and the NASA space station, and the AFSC military space system technology model. The program consists of combined contractual and in-house efforts aimed at understanding spacecraft environmental interaction phenomena and relating results of ground-based tests to space conditions. A concerted effort is being made to identify project-related environmental interactions of concern. The basic properties of materials are being investigated to develop or modify the materials as needed. A group simulation investigation is evaluating basic plasma interaction phenomena to provide inputs to the analytical modeling investigation. Systems performance is being evaluated by both groundbased tests and analysis. B.W.

N85-22518*# Air Force Geophysics Lab., Hanscom AFB, Mass.
INTERACTIONS MEASUREMENT PAYLOAD FOR SHUTTLE
D. A. GUIDICE and C. P. PIKE *In* NASA. Lewis Research Center Spacecraft Environ. Interactions Technol., 1983 p 609-618 Mar. 1985
Avail: NTIS HC A99/MF E03 CSCL 22B

The Interactions Measurement Payload for Shuttle (IMPS) consisted of engineering experiments to determine the effects of the space environment on projected Air Force space systems. Measurements by IMPS on a polar-orbit Shuttle flight will lead to detailed knowledge of the interaction of the low-altitude polar-auroral environment on materials, equipment and technologies to be used in future large, high-power space systems. The results from the IMPS measurements will provide direct input to MIL-STD design guidelines and test standards that properly account for space-environment effects. B.W.

N85-22523*# Rice Univ., Houston, Tex.
ARGON ION POLLUTION OF THE MAGNETOSPHERE
R. E. LOPEZ *In* NASA. Lewis Research Center Spacecraft Environ. Interactions Technol., 1983 p 675-692 Mar. 1985 refs
Avail: NTIS HC A99/MF E03 CSCL 04A

Construction of a Solar Power Satellite (SPS) would require the injection of large quantities of propellant to transport material from Low Earth Orbit (LEO) to the construction site at Geostationary

Earth Orbit (GEO). This injection, in the form of approx 10 to the 32nd power, 2 KeV argon ions (and associated electrons) per SPS, is comparable to the content of the plasmasphere (approx 10 to the 31st power ions). In addition to the mass deposited, this represents a considerable injection of energy. The injection is examined in terms of a simple model for the expansion of the beam plasma. General features of the subsequent magnetospheric convection of the argon are also examined. Author

N85-22582# Societe Europeenne de Propulsion, Vernon (France).
DEVELOPMENT AND TESTING OF A SPACECRAFT SURFACE POTENTIAL MONITOR
D. VALENTIAN, C. ROULLE, L. LEVY (ONERA, Toulouse), D. SARRAIL (ONERA, Toulouse), and J. C. LARUE (ESTEC, Noordwijk, Netherlands) *In* ESA Photovoltaic Generators in Space p 103-107 Nov. 1984 refs
Avail: NTIS HC A20/MF A01

A surface potential monitor was developed to measure the superficial electrostatic charging in solar cell covers and OSRs. The equipment correlates abrupt surface potential charges resulting from electrostatic discharges occuring during geomagnetic substorm events and spacecraft disturbances, and can also be used to drive an active spacecraft charging control system. The monitor must measure electrostatic fields up to 50 kW/mn and detect fields 100 times smaller. Temperature range is from minus 150 to + 80 C. It must sustain ionizing radiation and ultrahigh vacuum for 7 yr. Sensing area dimension is 20 x 20 mm. Height is 20 mm. Author (ESA)

N85-22583# Office National d'Etudes et de Recherches Aerospatiales, Toulouse (France). Dept. d'Etudes et de Recherches en Technologie.
PHENOMENOLOGY OF DISCHARGES IN SPACE: APPLICATION TO A SOLAR GENERATOR [PHENOMENOLOGIE DES DECHARGES DANS L'ESPACE: APPLICATION AU GENERATEUR SOLAIRE]
L. LEVY and D. SARRAIL *In* ESA Photovoltaic Generators in Space p 109-114 Nov. 1984 refs In FRENCH
Avail: NTIS HC A20/MF A01

A criterion of electric discharge between metal interconnections and protective filters was tested on a solar array model. The criterion states that there is a risk of discharge when the space environment induces a potential difference of 500 V between connection and filter, the connection being positive in relation to the filter. Tests show that the dielectric rigidity of the connector/filter coupling depends on the polarity of the potential difference. In the SPOT (French satellite) array discharges occur from 1000 V upwards. Author (ESA)

N85-23911# Max-Planck-Inst. fuer Kernphysik, Heidelberg (West Germany).
EXPERIMENTAL INVESTIGATIONS ON ION EMISSION WITH DUST IMPACT ON SOLID SURFACES
F. R. KRUEGER and J. KISSEL *In* ESA The Giotto Spacecraft Impact-Induced Plasma Environ. p 43-48 Sep. 1984 refs
Avail: NTIS HC A06/MF A01

Ion types, energy, and angular distributions of ions produced in dust particle impact simulations of the Giotto spacecraft Halley's comet encounter are reported, and semiempirical yield formulas are given. Results show that dust impact is the largest contribution to ion formation at the spacecraft surfaces during Halley encounter. The yield of ions formed by atomic and molecular impacts is comparably small. Due to the painted surface on the shield, negative ions are also formed. The number of electrons produced by dust and molecular impact together is less than expected, because in dust impact only a few residual electrons are liberated. This may be compensated by a higher electron production by molecular impacts and by light irradiation. However, the total electron yield, though probably less than the negative ion yield, is still large enough to govern the plasma properties due to the large mobility of the electrons. Author (ESA)

N85-25380# Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Engineering.
ANALYSIS OF SPACE STATION OPERATIONS IN THE SPACE DEBRIS ENVIRONMENT M.S. Thesis
B. M. WAECHTER Dec. 1984 268 p
(AD-A151872; AFIT/GOR/OS/84D-15) Avail: NTIS HC A12/MF A01 CSCL 22B

Analysis of Space Station operations in the space debris environment involved the conceptualization and development of a simulation model to provide initial estimates concerning Space Station survivability and fuel requirements. An initial review of recent literature indicated the relative insensitivity of satellite-of-interest collision probability calculations to modeling debris density with varying complexity. In addition, the literature identified that the debris population unable to be detected by current means, the rate of unintentional explosions and inter-object collisions, and the dynamics of these occurrences are important system parameters on which little is known. Conceptual model elements significantly affecting the space debris population and lending themselves to modeling were included in the discrete-event SLAM simulation model developed. The model simulated space debris environment dynamics up to Space Station system maturity. Model results indicated that at least one collision could occur within the first 29 years of Space Station operations. The results stress the need for greater consideration of the survivability of large, long-term spacecraft in such an environment, and for greater ground-tracking or on-board debris detection capabilities. GRA

N85-25381# MATRA Service Aerodynamique, Toulouse (France). Dept. d'Etudes et Avant Projets Systeme.
ESABASE EXTENSION TO SPACECRAFT CHARGING ANALYSIS. PHASE 1: NASCAP SOFTWARE (VAX VERSION) Final Report
M. FREZET 14 May 1984 48 p refs
(Contract ESTEC-5632/83/NL-PP)
(ESA-CR(P)-1968; MATRA-CMT-RT101/021) Avail: NTIS HC A03/MF A01

A VAX version of the NASCAP code was developed for use at system level to investigate spacecraft charging in geosynchronous orbit and in test tanks. The program was applied to the HIPPARCOS spacecraft. Author (ESA)

N85-34164*# TRW, Inc., Redondo Beach, Calif.
WAVES IN SPACE PLASMAS (WISP) Abstract Only
W. W. L. TAYLOR *In* Alabama Univ. Coordinated Study of Solar-Terrestrial Payloads on Space Station 2 p 1985
Avail: NTIS HC A04/MF A01 CSCL 14B

Waves in space plasmas (WISP) utilizes powerful radio transmitters and sensitive receivers to probe the secrets of the magnetosphere, ionosphere and atmosphere. The scientific objective is to achieve a better understanding of the physical processes occurring in these regions. For example, audio frequency radio waves will be radiated from the long WISP antenna, will travel to the outer reaches of the magnetosphere, and will interact with Van Allen belt particles, releasing some of their energy which amplifies the waves. Study of this interaction will give us a better understanding of a major magnetospheric process, wave particle interactions. Radio waves from WISP at higher frequencies (AM radio and beyond) will be reflected by the ionosphere and will, for example, advance our understanding of bubbles in the equatorial ionosphere which affect satellite communications. Author

N85-34171*# Southwest Research Inst., San Antonio, Tex.
MAGNETOSPHERIC MULTIPROBES: MMP/CHEMSAT Abstract Only
J. BURCH *In* Alabama Univ. Coordinated Study of Solar-Terrestrial Payloads on Space Station 2 p 1985
Avail: NTIS HC A04/MF A01 CSCL 14B

The magnetospheric multiprobes (MMP) are a set of ejectable, self contained, limited lifetime free flyers which are designed to make plasma diagnostic measurements at multiple locations within telemetry range of the space station's coorbiting platform and polar platform. When configured as CHEMSATs, one or more

MMP's will conduct chemical releases as tracers or modifiers of the local plasma and field environment, while diagnostic measurements are made from other MMP's and from the nearby platform. The probes will be battery powered and will have lifetimes of a few days to several weeks. Up to 12 probes would be placed on the coorbiting platform and the polar platform every six months and two years respectively for use in the campaign mode of operation. Author

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INTERNATIONAL

Includes descriptions, interfaces and requirements of international payload systems, subsystems and modules considered part of the Space Station system and other international Space Station activities such as the Soviet Salyut.

A85-31096#
EUROPEAN ASPECTS OF USING THE SPACE STATION
K. K. REINHARTZ (ESA, Systems Engineering Dept., Noordwijk, Netherlands) ESA Bulletin (ISSN 0376-4265), no. 41, Feb. 1985, p. 42-50.

European participation in the NASA Space Station program is discussed with an emphasis on ongoing efforts to facilitate, through ESA, its use as laboratory, observatory, transportation node, repair facility for other spacecraft, and manufacturing and assembly facility. Consideration is given to the manned and unmanned elements of the current architecture concept, the identification of potential users and their needs, possible conflicts and overlaps between different user communities, and the processes involved in advancing from model missions to actual design requirements. Diagrams, drawings, photographs, and tables listing the European model missions in material science, life sciences, astronomy and solar-system science, earth observation, communications, and technology development are provided. T.K.

A85-33074
COLUMBUS - THE EUROPEAN ROLE
T. FURNISS Space World (ISSN 0038-6332), vol. V-3-256, April 1985, p. 21-23.

European participation in the Space Station effort is asserted to be part of an intent to build a subsequent autonomous European space complex serviced by the Hermes mini-Shuttle. The European station, already named the Columbus, is presently receiving a technical analysis. The definition studies will begin in 1986. A manned module will be launched by the Shuttle and become part of the NASA Space Station, then will be followed by an unmanned platform, most likely in polar orbit. The manned unit could be either linked to the Space Station or fly in formation with it. The conditions for European cooperative efforts with NASA have been defined, and include access to the Station and all related facilities, protection of proprietary contributions and an absence of discrimination against European users. M.S.K.

A85-33439#
TWO HUNDRED THIRTY-SEVEN DAYS IN SALYUT-7
K. FEOKTISTOV Aerospace America (ISSN 0740-722X), vol. 23, May 1985, p. 96-98.

The Salyut-7 mission which occupied that station on February 9, 1984, lasted until October 2, 1984 and thereby became the longest orbital stay in the history of manned space flight. Three manned Soyuz-T spacecraft and five Progress cargo ships supported operations during these 237 days, with the latter delivering food, water, air regenerators, CO2 absorbers, clothes, scientific equipment, and medical and biological supplies for research experiments. Astrophysical observations, earth surface observations, and crystallographic and biomedical studies were conducted. An Indian crew visited Salyut-7. O.C.

A85-33598
THE USE OF SPACE PHOTOGRAPHS FOR LANDSCAPE MAPPING [ISPOL'ZOVANIE KOSMICHESKIKH SNIMKOV PRI LANDSHAFTNOM KARTOGRAFIROVANII]
T. V. VERESHCHAKA, B. V. KRASNOPEVTSEVA, and V. V. USOVA (Moskovskii Institut Inzhenerov Geodezii, Aerofotos'emki i Kartografii, Moscow, USSR) Geodeziia i Aerofotos'emka (ISSN 0536-101X), no. 1, 1985, p. 99-103. In Russian.

Results of a landscape analysis of Salyut-5 photographs of the earth surface are presented. The study was carried out with the aim of compiling a landscape map of a region of Central Asia. B.J.

A85-33759
THE POSTURE EXPERIMENT
F. LESTIENNE (CNRS, Laboratoire de Physiologie Neurosensorielle, Paris, France), J. L. LAFON (Societe Bertin et Cie., Plaisir, Yvelines, France), and E. CAPRARO (Centre National d'Etudes Spatiales, Paris, France) AIAA, SAE, ASME, AIChE, and ASMA, Intersociety Conference on Environmental Systems, 14th, San Diego, CA, July 16-19, 1984. 10 p. refs
(SAE PAPER 840948)

During the flight of the French astronaut Chretien aboard the Soviet Space Station Salyut 7 an experiment called Posture, aiming to study the principles governing the adaptation of the posture control mechanisms in 0g environment was conducted. The results obtained before, during and after the flight with the specific equipment developed by the Bertin Company, show there are two types of adaptation of the central program of posture regulation to weightlessness: a fast adaptation, appearing at the beginning of the flight and a slow adaptation which is seen at the end of the flight. Author

A85-34133#
SPACE-STATION PROGRAMS IN THE U.S. AND EUROPE [RUIMTESTATIONPROGRAMMA'S IN DE VS EN EUROPA]
D. DE HOOP (Nederlands Instituut voor Vliegtuigontwikkeling en Ruimtevaart, Delft, Netherlands) Ruimtevaart, vol. 34, Feb. 1985, p. 2-16. In Dutch.

The scientific aims and design concept of the NASA Space Station program are summarized, and ESA participation in its development is discussed with a focus on the role of the Netherlands. The history of NASA Space-Station planning is traced; the components of the current design concept are introduced and illustrated with drawings and diagrams; and consideration is given to the arguments for European participation, the Italian-German Columbus concept for the ESA contribution, microgravity and astronomical investigations using the Space Station, the types of Station equipment to be built by Netherlands industries, and the program costs ($12 billion, of which $4 billion are to be provided by U.S. industry, ESA, Japan, and Canada). T.K.

A85-34220
GERMANY CITES COMMERCIAL FALLOUT AS JUSTIFICATION FOR U.S. STATION INVOLVEMENT
M. FEAZEL Commercial Space (ISSN 8756-4831), vol. 1, Spring 1985, p. 47, 49, 51, 54.

In January, West Germany agreed to provide about $1 billion to Columbus (total cost $2.4 billion), which represents the European contribution to the U.S. Space Station project. The design of Columbus will be derived from the design of Spacelab, the European-built laboratory which is carried in the cargo bay of the Space Shuttle. The German contribution to Columbus was approved by the German Bundestag only on condition that the investment would result in a commercial return. Questions regarding the commercialization of the Space Station are discussed, taking into account also developments related to the flight of the SPAS with the Space Shuttle. G.R.

A85-34284
PLANT GROWTH, DEVELOPMENT AND EMBRYOGENESIS DURING SALYUT-7 FLIGHT
A. J. MERKYS, R. S. LAURINAVICIUS, and D. V. SVEGZDIENE (Akademiia Nauk Litovskoi SSR, Institut Botaniki, Vilnius, Lithuanian SSR) (COSPAR, Topical Meeting on Life Sciences and Space Research XXI(1), Graz, Austria, June 25-July 7, 1984) Advances in Space Research (ISSN 0273-1177), vol. 4, no. 10, 1984, p. 55-63. refs

The results of two experiments carried out in 1982 on board the orbital station Salyut 7 are presented. The first experiment, performed with the help of the station-borne centrifuge, investigates the character of the initial growth phases and the performance of tropical movements of roots and hypocotyls of lettuce under spaceflight conditions. The length of the hypocotyls on the centrifuge at 0.1 and 0.01 g and under weightlessness, is found to increase by 8-16 percent, whereas the length of the roots decreases by 17 percent at 0.01 g and under weightlessness. In the second experiment, an attempt is made to grow the plants of Arabidopsis on board the station achieving a full cycle of biological development. It is shown that the seeds sown during the flight germinated, performed growth processes, formed vegetative and generative organs, and succeeded in fecundation, embryogenesis, and ripening. M.D.

A85-34285
THE INFLUENCE OF SPACE FLIGHT FACTORS ON VIABILITY AND MUTABILITY OF PLANTS
L. KOSTINA, I. ANIKEEVA, and E. VAULINA (Akademiia Nauk SSSR, Institut Obshchei Genetiki, Moscow, USSR) (COSPAR, Topical Meeting on Life Sciences and Space Research XXI(1), Graz, Austria, June 25-July 7, 1984) Advances in Space Research (ISSN 0273-1177), vol. 4, no. 10, 1984, p. 65-70. refs

Experiments carried out on the Soyuz 16 spacecraft and the orbital stations Salyut 5, 6, and 7, in which air-dried Crepis capillaris seeds were used to study cytogenetic effects in seedlings, are reported. The experiments reveal an increase in the frequency of chromosome aberrations in seedlings grown from flight-exposed seeds during the flight and after the flight on earth as compared to a ground-based control. An analysis of fruits from Arabidopsis thaliana plants grown during the flight in a Light block-1 device shows an increase in the frequency of recessive mutants and a reduction in plant fertility. The germinating ability of seeds from Arabidopsis plants grown in space in a Fiton-3 device and the survival of the next generation of plants from these seeds are reduced. It is shown that in the first postflight generation, damages resulting from chromosome aberrations are eliminated, whereas those resulting from gene mutations and microaberrations are preserved for a longer time. M.D.

A85-34286
CHANGES IN DEVELOPMENTAL CAPACITY OF ARTEMIA CYST AND CHROMOSOMAL ABERRATIONS IN LETTUCE SEEDS FLOWN ABOARD SALYUT-7 - BIOBLOC III EXPERIMENT
V. NEVZGODINA, E. E. KOVALEV, E. N. MAKSIMOVA (Ministerstvo Zdravookhraneniia SSSR, Institut Mediko-Biologicheskikh Problem, Moscow, USSR), Y. GAUBIN, H. PLANEL, G. GASSET, B. PIANEZZI (Toulouse III, Universite, Toulouse, France), and J. CLEGG (Miami, University, Coral Gables, FL) (COSPAR, Topical Meeting on Life Sciences and Space Research XXI(1), Graz, Austria, June 25-July 7, 1984) Advances in Space Research (ISSN 0273-1177), vol. 4, no. 10, 1984, p. 71-76. refs

This paper gives the results of investigations performed on the first container (A) of the Bioblock III experiment, flown aboard the orbital station Salyut 7 for 40 days. The space flight resulted in a decreased developmental capacity of Artemia cysts, hit or not hit by the HZE particles. No effect was observed in cysts in bulk. A synergetic effect of microgravity and gamma pre irradiation is described. The germination of in-flight lettuce seeds was decreased. The space flight resulted also in a higher percentage of cells with chromosomal aberrations. Relations between biological response, TEL and location of HZE particles are discussed. Author

A85-34287
THERMOLUMINESCENT DOSE MEASUREMENTS ON-BOARD SALYUT TYPE ORBITAL STATIONS
IU. A. AKATOV, V. V. ARKHANGELSKII (Ministerstvo Zdravookhraneniia SSSR, Institut Mediko-Biologicheskikh Problem, Moscow, USSR), A. P. ALEKSANDROV (Akademiia Nauk SSSR, Sovet Interkosmos, Moscow, USSR), I. FEHER, S. DEME, B. SZABO, J. VAGYOLGYI, P. P. SZABO, A. CSOKE, M. RANKY (Magyar Tudomanyos Akademia, Kozponti Fizikai Kutato Intezet, Budapest, Hungary) et al. (COSPAR, Topical Meeting on Life Sciences and Space Research XXI(1), Graz, Austria, June 25-July 7, 1984) Advances in Space Research (ISSN 0273-1177), vol. 4, no. 10, 1984, p. 77-81. refs

Dosimetric experiments with the PILLE thermoluminescent dosemeter system, performed on the Salyut space station in 1980 and 1981 and on Salyut-7 in 1983 to study the dose-field distribution in the inhabited sections of the space stations and to determine the personal dose burdens of the crew during the space flight, are described. The results of dose-field measurements on Salyut-6, in which rates varied from 0.07 to 0.11 mGy/day, are presented. The dose rates (0.12-0.23 mGy/day) measured on Salyut-7, which employed a new PILLE system with an improved sensitivity of 1 micro Gy/digit, are also given. It is shown that the apparatus has applications for dose control during space walks and for phantom experiments. M.D.

A85-34290
BIOLOGICAL CHANGES OBSERVED ON RICE AND BIOLOGICAL AND GENETIC CHANGES OBSERVED ON TOBACCO AFTER SPACE FLIGHT IN THE ORBITAL STATION SALYUT-7 - BIOBLOC III EXPERIMENT
J. BAYONOVE, M. BURG, A. MIR (Montpellier II, Universite Montpellier, France), and M. DELPOUX (Toulouse III, Universite, Toulouse, France) (COSPAR, Topical Meeting on Life Sciences and Space Research XXI(1), Graz, Austria, June 25-July 7, 1984) Advances in Space Research (ISSN 0273-1177), vol. 4, no. 10, 1984, p. 97-101. refs

Caryopses and isolated embryos from Rice (Oryza sativa L.) and Tobacco seeds (Nicotiana tabacum L. variety Xanthi) were studied in the Biobloc III container aboard the Soviet orbital space station Salyut 7. The recovery from radiation damage under conditions of space flight was observed for rice caryopsis and embryos gamma irradiated (Co 60, 50 grays) prior to launch. There was a large decrease in the percentage of germinating seeds from the Tobacco strain tested when the seeds were exposed to heavy ions. Among the germinating plantlets there were few morphological anomalies. Furthermore, there was a significant greater amount of genetic change in those samples held in grids as compared to those in bags. Author

A85-34291
RADIOSENSIBILITY OF HIGHER PLANT SEEDS AFTER SPACE FLIGHT
E. VAULINA, I. ANIKEEVA, and L. KOSTINA (Akademiia Nauk SSSR, Institut Obshchei Genetiki, Moscow, USSR) (COSPAR, Topical Meeting on Life Sciences and Space Research XXI(1), Graz, Austria, June 25-July 7, 1984) Advances in Space Research (ISSN 0273-1177), vol. 4, no. 10, 1984, p. 103-107. refs

In experiments performed on the orbital stations Salyut 6 and 7, the influence of long-term storage of Crepis capillaris and Arabdiopsis thaliana seeds under space flight conditions on seed radio-sensitivity is studied. It is shown that the radiosensitivity of C. capillaris seeds is not affected by short-terms storage, while in the case of maximal exposure duration, the chromosome aberration frequency, in post-flight irradiated seeds exceeds chromosome aberration frequency in the ground-based irradiated control. An increase in the number of cells with multiple chromosome aberrations is also observed. After exposure to gamma-irradiation and with the prolongation of seed storage, the germinating ability of A thaliana seeds and the survival rate of the plants decreases. Flight-exposed seeds are found to be more sensitive to irradiations with respect to these parameters. In two experiments of

long-exposure duration, an increase in the recessive lethal mutation frequency is observed. M.D.

A85-36418
EUROPE'S COOPERATIVE SPACE EFFORTS EXPAND AS COSTS, COMPLEXITY GROW
J. M. LENOROVITZ Aviation Week and Space Technology (ISSN 0005-2175), vol. 122, June 3, 1985, p. 137, 141, 143, 147.

ESA gas received budget increases which will permit the expansion of science programs. Due to the U.S. refusal to build a second International Solar Polar Mission (ISPM) spacecraft, ESA projects will follow cooperative, complementary directions with NASA efforts, but will not be performed in full partnership. NASA will still launch the ISPM spacecraft: An ESA spacecraft will in the near future gather high spectral resolution X ry data, while the U.S. AXAF platform will acquire high spatial and/or angular resolution X ray data. ESA is planning a platform which will hold scientific and other apparatus, for a co-orbit with the Space Station. NASA may fund experiments for the ESA SOHO satellite for solar-terrestrial physics studies. NASA and ESA may also share funds and technical support for future planetary missions such as the Cassini spacecraft, which would drop a probe onto the Saturn moon Titan. M.S.K.

A85-36420
SPACELAB SERVES AS FOUNDATION FOR FUTURE NASA/ESA COOPERATION
Aviation Week and Space Technology (ISSN 0005-2175), vol. 122, June 3, 1985, p. 195, 197, 199.

NASA/ESA cooperative efforts are, on a political level, still tenuous, but on a working level, nearly those of the same organization. It is felt that companies which participated in development of the Spacelab will also join in Space Station endeavors. Less documentation is required on the ESA side, which is still involved deeply with expendible boosters. ESA personnel who worked on Spacelab at the Johnson Center, however, have expressed concerns that the STS has too many expendable components. The documentation levels required by NASA have aided European managers in producing Spacelab, which has proven sufficiently well-designed and engineered to schedule it on 10 of he next 30 STS missions. M.S.K.

A85-36446
SPACE: A DEVELOPING ROLE FOR EUROPE; PROCEEDINGS OF THE EIGHTEENTH EUROPEAN SPACE SYMPOSIUM, LONDON, ENGLAND, JUNE 6-9, 1983
L. J. CARTER, ED. (British Interplanetary Society, London, England) and P. M. BAINUM, ED. (Howard University, Washington, DC) Symposium sponsored by the Association Aeronautique et Astronautique de France, DGLR, AAS, et al. San Diego, CA, Univelt, Inc. (Science and Technology Series. Volume 56), 1984, 277 p. For individual items see A85-36447 to A85-36450.

Current and planned European space projects are examined in reviews and reports and illustrated with diagrams and drawings. Topics discussed include facilities for life-science research in space, ESA microgravity research, the ERS-1 ice and ocean monitoring satellite, precision laser tracking for global tectonics, the ESA telecommunications program, the FUV Spectroscopic Explorer, the first 4 mo of IRAS observations, and the implications of grant-back clauses for international joint ventures in space technology. Consideration is given to the airplane approach to launch-vehicle design, the Ariane-5/Hermes project, the potential market for low-cost launch vehicles, space-station concepts and utilization potential, alternative European approaches to a manned space station, and opportunities for international participation in the US planetary-exploration program. T.K.

A85-36449
ALTERNATIVE EUROPEAN APPROACHES TO A MANNED SPACE STATION FOR EUROPEAN PARTICIPATION
W. LEY (Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Stabsabteilung Programmvorbereitung, Cologne, West Germany) IN: Space: A developing role for Europe; Proceedings of the Eighteenth European Space Symposium, London, England, June 6-9, 1983 . San Diego, CA, Univelt, Inc., 1984, p. 219-256.
(AAS PAPER 83-520)

The possibilities for European participation in the NASA Space Station program are discussed, summarizing the findings of studies conducted for ESA in 1982-1983 by an industry group headed by DFVLR. Consideration is given to the scientific and technological utilization potential of different station concepts, identification of mission candidates and their payload requirements, and manned or unmanned alternatives to the space station for the same goals. Diagrams, drawings, extensive tables listing the advantages/disadvantages of a station for specific missions, and a summary of the primary objectives and secondary benefits of European participation are provided. It is concluded that Europe will contribute mainly basic-research payloads for the life sciences, space technology, and material science, while unmanned free flyers will still be required for automated materials processing, astronomy, and earth remote sensing. T.K.

A85-38435
EUROPE - TOWARDS AUTONOMY IN SPACE
J. MOXON Flight International (ISSN 0015-3710), vol. 127, June 1, 1985, p. 103-106.

In January 1985, the member governments of the ESA met in Rome and decided unanimously to undertake a program for the achievement of total independence in the conduct of space activities by the year 1997. Autonomy is defined by ESA as the ability to place satellites in orbit by means of reliable launch facilities, the possession of free access to a Space Station, and the operation of a manned 'space taxi' to effect that access to the space station. The Rome meeting nevertheless proceeded to approve and fund plans for participation in NASA's Space Station program, to which ESA's primary contribution will probably be the Columbus pressurized module for use as a 'plug-in' manned laboratory. A servicing vehicle and resources module are also envisioned. The servicing vehicle, which unlike the Space Shuttle will not be used to launch satellites, is the Hermes reusable craft. O.C.

A85-38902#
SPACE - THE CHALLENGE OF A NEW ENVIRONMENT
H. L. JORDAN (Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Cologne, West Germany) IN: Symposium on Industrial Activity in Space, Stresa, Italy, May 2-4, 1984, Proceedings . Paris, Eurospace, 1984, p. 5-26.

The history, current status, and future plans for industrial activity in space are surveyed from a European perspective. Topics discussed include the early history of space flight; the progress of remote-sensing technology; the nature of the space environment at altitude 500 km; the effects of microgravity on physical processes of industrial importance; steps to be taken by industry to prepare to take advantage of space processing opportunities; the ongoing rocket-borne TEXUS and STS-borne MAUS, GAS, and Spacelab experiments in material science; legal and organizational aspects of space industrialization; and planned European participation in the NASA Space Station. Photographs, drawings, diagrams, and graphs are provided. T.K.

A85-39076* Naples Univ. (Italy).
SPACELAB TO SPACE STATION; PROCEEDINGS OF THE INTERNATIONAL SYMPOSIUM ON SPACELAB 1 - RESULTS, IMPLICATIONS AND PERSPECTIVES, NAPLES AND CAPRI, ITALY, JUNE 11-16, 1984
L. G. NAPOLITANO, ED. (Napoli, Universita, Naples, Italy) Symposium sponsored by the Universita di Napoli, Aeritalia S.p.A., ESA, and NASA. Earth-Oriented Applications of Space Technology (ISSN 0277-4488), vol. 5, no. 1-2, 1985, 169 p. For individual items see A85-39077 to A85-39096.

Consideration is given to the scientific objectives of the Spacelab program, a review of data obtained during the STS-9/Spacelab 1 mission on board the Shuttle, and the coordination of future Spacelab research among participating European nations. Among the specific fields of study covered by Spacelab 1 were space plasma physics, materials and fluid sciences and technology, astronomy and solar physics, and atmospheric physics and earth observations. Consideration is also given to the legal aspects of space manufacturing activities, the role of private industry in space-based manufacturing ventures, plant production and breeding in space, and the development of remote sensing systems for use in a microgravity environment. I.H.

A85-40334#
A SYSTEMS-ANALYSIS COMPARISON OF SPACE STATION PROJECTS [SYSTEMTECHNISCHER VERGLEICH VON RAUMSTATIONSPROJEKTEN]
E. IGENBERGS (Muenchen, Technische Universitaet, Munich, West Germany) Deutsche Gesellschaft fuer Luft- und Raumfahrt, Jahrestagung, Hamburg, West Germany, Oct. 1-3, 1984. 21 p. In German.
(DGLR PAPER 84-118)

Igenbergs (1984) has compared the benefits obtainable for Europe in the case of the development of a European space station with the advantages obtained in the case of a participation in the U.S. Space Station program. He found that the latter possibility represents the better solution. The present investigation is concerned with the conduction of a systems analysis regarding the characteristics of the various alternatives or scenarios which appear feasible. Attention is given to the representation of the scenarios, the evaluation of the scenarios, the various elements and properties, details regarding the examined scenarios, and a description of the interaction matrices. A participation in the U.S. Space Station program according to two alternatives is considered, including one involving manned and unmanned elements, and another involving only unmanned elements. G.R.

A85-40335#
REQUIREMENTS FOR THE CONSTRUCTION AND OPERATION OF A EUROPEAN SPACE STATION. I - EUROPEAN ASPECTS OF UTILIZATION [ANFORDERUNGEN FUER BAU UND BETRIEB EINER EUROPAEISCHEN RAUMSTATION. I - EUROPAEISCHE NUTZUNGSASPEKTE]
H. ANTON and W. LEY (DFVLR, Cologne, West Germany) Deutsche Gesellschaft fuer Luft- und Raumfahrt, Jahrestagung, Hamburg, West Germany, Oct. 1-3, 1984. 21 p. In German.
(DGLR PAPER 84-119)

In connection with the plans of the U.S. for the establishment of a Space Station, a number of other nations have been invited to participate in the design of such a station. In response to this invitation, studies have been conducted in Europe to examine the possibilities for a cooperation between Europe and the U.S. with respect to the Space Station program. These studies were partly concerned with the various aspects of a utilization of a space station by European countries. Of particular interest appeared to be a permanent, manned laboratory in space for activities utilizing microgravity and facilities for in-orbit servicing. Attention is given to the employment of a pressurized module (PM) as laboratory and habitat for the astronauts, a platform as carrier for payloads which have to be exposed to the space environment, a resource module (RM), and a servicing vehicle (SV). A participation in the U.S. Space Station program makes it possible for European users to explore the considered new approaches without sacrificing the feasibility of autonomy. G.R.

A85-41300
THE GAGARIN SCIENTIFIC LECTURES ON ASTRONAUTICS AND AERONAUTICS. 1982 [GAGARINSKIE NAUCHNYE CHTENIIA PO KOSMONAVTIKE I AVIATSII. 1982 G.]
A. IU. ISHLINSKII, ED. Moscow, Izdatel'stvo Nauka, 1984, 264 p. In Russian. No individual items are abstracted in this volume.

Topics discussed include long-term multipurpose orbital stations; systems methodology for the strength analysis and design of aerospace structures; the use of the FRONT computing system for the design of thin-walled reinforced structures; the flights of Venera-13 and Venera-14; the remote sensing of earth resources; biomedical problems in space flight; and the design of temperature control systems for flight vehicles. Consideration is also given to aspects of navigation of the Salyut-6 - Soyuz - Progress complex; display systems in training simulators; the design of control systems for spin-stabilized spacecraft; thermal and gasdynamic problems in space flight; power systems for flight vehicles; and space manufacturing. B.J.

A85-41859
A SOLAR-PUMPED LASER ON THE SPACE STATION
H. ARASHI, Y. OKA, and M. ISHIGAME (Tohoku University, Sendai, Japan) (University of Tokyo and Ministry of Education, Science, and Culture, Space Energy Symposium, 3rd, Tokyo, Japan, Mar. 26, 1984) Space Solar Power Review (ISSN 0191-9067), vol. 5, no. 2, 1985, p. 131-133.

A solid state solar pumped laser system to be used on the Space Station is described. The system is based on an experimental version of a solar pumped Nd:YAG laser which has achieved a maximum power in excess of 18 W in multi-mode. The laser is powered by a paraboloid solar radiation concentrator. A solar pumped gas laser system is recommended for applications requiring a higher output power. Applications of a laser on board the Space Station include optical communication; laser propulsion; energy conversion; and high speed laser processing. Detailed schematic drawings of the solid state and gas laser designs are provided. I.H.

A85-41863
MICROWAVE ENERGY TRANSMISSION TEST TOWARD THE SPS USING THE SPACE STATION
N. KAYA (Kobe University, Japan), H. MATSUMOTO (Kyoto University, Uji, Japan), S. MIYATAKE (University of Electro-Communications, Chofu, Japan), I. KIMURA (Kyoto University, Japan), and M. NAGATOMO (Tokyo, University, Japan) (University of Tokyo and Ministry of Education, Science, and Culture, Space Energy Symposium, 3rd, Tokyo, Japan, Mar. 26, 1984) Space Solar Power Review (ISSN 0191-9067), vol. 5, no. 2, 1985, p. 163-169. refs

An outline of a project METT (Microwave Energy Transmission Test) using the Space Station is described. The objectives of the METT are to develop and test the technology of microwave energy transmission for the future Solar Power Satellite (SPS), and to estimate the environmental effects of the high power microwaves on the ionosphere and the atmosphere. Energy generated with solar cells is transmitted from a transmitting antenna on the bus platform near the Space Station to a rectenna on the sub-satellite or the ground station in order to test the total efficiency and the functions of the development system of the energy transmission. Plasma similar to that in the D and E layers in the ionosphere is produced in a large balloon opened on the sub-satellite in order to investigate possible interactions between the SPS microwave and the ionospheric plasma and to determine the maximum power density of the microwave beam which passes through the ionosphere. Author

A85-41866
SPACE SEMICONDUCTOR PROCESSING FACTORY
I. KUDO and H. FUJISADA (Ministry of International Trade and Industry, Electrotechnical Laboratory, Sakura, Japan) (University of Tokyo and Ministry of Education, Science, and Culture, Space Energy Symposium, 3rd, Tokyo, Japan, Mar. 26, 1984) Space Solar Power Review (ISSN 0191-9067), vol. 5, no. 2, 1985, p. 189-195. refs

Consistent material processing from crystal growth of bulky material to highly integrated devices is proposed. Especially, feasibility of automated dry microfabrication process in space is discussed. Space has some beneficial characteristics about high-vacuum environment as well as zero-gravity field. Author

A85-41876
SALYUT-6 - SOYUZ: MATERIALS SCIENCE AND TECHNOLOGY ['SALIUT-6' - 'SOIUZ': MATERIALOVEDENIE I TECHNOLOGIIA]
IU. A. OSIPIAN, ED. and L. L. REGEL, ED. Moscow, Izdatel'stvo Nauka, 1985, 184 p. In Russian. For individual items see A85-41877 to A85-41900.

The papers presented in this volume contain some results of experiments conducted under the Intercosmos program. Subjects discussed include the effect of microgravity on the distribution of inhomogeneities in molten glass, the effect of convection on the chemical transport of Ge by iodine, a study of the formation and solidification of an iron-zinc alloy under conditions of microgravity, and the formation of gas inclusions in melts in microgravity. Other contributions include the production of aluminum foam under conditions of microgravity, a backscattering spectrometry and PIXE study of GaSb and GaAs crystals grown in microgravity, and a study of heat and mass transfer under various conditions of the growth of GaP crystals from a solution. V.L.

A85-42552
FROM SPACELAB TO SPACE STATION; PROCEEDINGS OF THE FIFTH SYMPOSIUM, HAMBURG, WEST GERMANY, OCTOBER 3-5, 1984
H. STOEWER, ED. (ESA, European Space Research and Technology Centre, Noordwijk, Netherlands) and P. M. BAINUM, ED. (Howard University, Washington, DC) Symposium sponsored by AAS, DGLR, and AIAA. San Diego, CA, Univelt, Inc. , 1985, 269 p. For individual items see A85-42553 to A85-42559.

West German participation in the NASA STS program and the planned Space Station is discussed in reviews and reports. Topics examined include German space policy for the period 1985-1995, Spacelab flight results, the system architecture and technology for the Space Station, and Space Station plans. Diagrams, photographs, and drawings are provided, and a list of STS missions and payloads from STS-1 in 1981 through STS-101 in 1989 is included in an appendix. T.K.

A85-42553
REMARKS ON GERMAN SPACE POLICY - 1985 TO 1995
W. FINKE (BMFT, Bonn, West Germany) IN: From Spacelab to Space Station; Proceedings of the Fifth Symposium, Hamburg, West Germany, October 3-5, 1984 . San Diego, CA, Univelt, Inc., 1985, p. 3-15.
(AAS PAPER 84-319)

The participation of the Federal Republic of Germany (FRG) in European and NASA space programs in the coming decade is discussed by a government official favoring such participation. Current FRG space R&D efforts (primarily in cooperation with the US and France) are surveyed; plans for the Columbus program (ESA's main contribution to the Space Station) and the follow-on development of the ESA Ariane launcher series (based on the HM-60 large cryogenic engine) are characterized; the projected costs of these programs (about 2.7 billion AU each) are indicated; the arguments for and against an extensive manned presence in space (for scientific and commercial missions) are reviewed; and the political consequences of an FRG decision for or against participation are considered. FRG goals with regard to the Space Station include clarification of its nonmilitary status, maintaining the option to use ESA components in an eventual European space station or to use Ariane for component launches, limitations and predictability vis-a-vis costs, and assurances of equal partnership (fair evaluation of services provided by each partner; guaranteed necessary transport, supply, and data-transmission services on most-favored-nation status; unrestricted scientific and commercial use of results; and unlimited technology transfer for development and commercial utilization). T.K.

A85-42555
TECHNOLOGY DEVELOPMENTS FROM SPACELAB TO SPACE STATION
W. WIENSS (ERNO Raumfahrttechnik GmbH, Bremen, West Germany) IN: From Spacelab to Space Station; Proceedings of the Fifth Symposium, Hamburg, West Germany, October 3-5, 1984 . San Diego, CA, Univelt, Inc., 1985, p. 103-110.
(AAS PAPER 84-308)

Technological aspects of the Columbus program, the ESA development of a manned laboratory module, an unmanned resource module and payload carrier, and a manned service vehicle for use in the NASA Space Station, are discussed and illustrated with charts and drawings. Consideration is given to the design requirements and the technology options available to meet them, systems-related and operations-related technology (space/ground assembly, testing, and verification; on-orbit servicing; automation and autonomy; exploitation of human capabilities; and long-life aspects), and subsystem-related technology (with a focus on the applications of high-data-rate processing and transmission capabilities). T.K.

A85-42559
THE COLUMBUS CONCEPT
H. SAX (DFVLR, Cologne, West Germany) IN: From Spacelab to Space Station; Proceedings of the Fifth Symposium, Hamburg, West Germany, October 3-5, 1984 . San Diego, CA, Univelt, Inc., 1985, p. 191-204.
(AAS PAPER 84-316)

Current plans for Columbus, a program of spacecraft and modules being developed as the main ESA contribution to the NASA Space Station project, are reviewed and illustrated with charts and drawings. The Columbus proposal comprises a space segment (pressurized laboratory, habitat, or logistics module; payload carrier; resource module; and manned service and transport vehicle), a ground segment (providing hardware checkout and integration, experiment preparation and support, mission simulation and training, payload-operations control, mission control, and a data-communications net including a data-relay satellite), a long-term utilization plan, and a supporting technology program. T.K.

A85-42694#
SPACELAB AND EURECA AS A BASIS FOR EUROPEAN INVOLVEMENT IN THE SPACE STATION
R. MORY (ESA, Directorate of Space Transportation Systems, Paris, France) ESA Bulletin (ISSN 0376-4265), no. 42, May 1985, p. 30-38.

The Eureka free-flyer and Spacelab are seen as major contributors to European participation in the Space Station program. A consortium of European manufacturers has invested a billion dollars in Spacelab, which was developed with NASA guidance. Spacelab supports experiments in tribology, fluid physics, crystal growth, biology and metallurgy. Eureka stays in orbit up to 6 mos before retrieval by the Shuttle, is capable of demonstrating the feasibility of Space Station components and technologies, provides co-orbiting unmanned platforms for the Space Station, and serves as a learning tool for payload preparation by European industries. Both the Spacelab and Eureka are prototype elements of the polar-orbiting Columbus component of the Space Station. The Columbus could include pressurized modules and could also co-orbit with the Space Station. M.S.K.

A85-44399
REFUELLING SALYUT SPACE STATIONS BY PROGRESS TANKERS
P. MILLS British Interplanetary Society, Journal (Space Chronicle) (ISSN 0007-084X), vol. 38, Aug. 1985, p. 381-384. refs

Design details of the Progress tanker spacecraft are outlined, along with the procedures followed in refueling operations. Progress consists of a cargo, fuel and oxidizer compartments and an instrument/assembly module. High pressure nitrogen gas is used to squeeze UDMH and nitrogen tetroxide bladders when transferring fuel to the Salyut space station. The receptacles on the space station have been the same on both Salyut 6 and 7 space stations. The fuel and oxidizer are transferred through connections in the rear docking ring of the station. The entire process can be guided by ground control or the station crew. The operation lasts several days because of the electricity demands on the station. Fuel and oxidizer are fed into separate tanks at different times to avoid hazards posed by leaks. The connecting lines are purged with nitrogen once the transfers are complete. M.S.K.

A85-47043#
COLUMBUS - EUROPE'S PIECE OF THE SPACE STATION
E. VALLERANI and P. PIANTELLA (Aeritalia S.p.A., Gruppo Sistemi Spaziali ed Energie Alternative, Turin, Italy) Aerospace America (ISSN 0740-722X), vol. 23, Sept. 1985, p. 72-74, 76.

In conjunction with the NASA Space Station project, the European Space Agency is now designing a manned free-flying system, Columbus. Columbus (which is based on the Spacelab concept, and designed for use by the international community) will consist, in its final stage of development, of four basic elements: the pressurized module (PM), containing the laboratory equipment; the unmanned platform, for earth observations and microgravity experiments; the resource module, supporting the PM by supplying power, attitude control, propulsion, and communication facilities; and the manned service vehicle, which will transport crew from the Space Station. In the final stage, several simultaneously flying Columbus systems are visualized, in which more than one laboratory module will be attached to the same flyer, visited by the same service vehicle. I.S.

A85-48100
EURECA - EUROPEAN FREE-FLYER
T. FURNISS Flight International (ISSN 0015-3710), vol. 128, Aug. 31, 1985, p. 30, 31.

The ESA's Eureca orbital platform is a microgravity experiment carrier which can remain in high orbit for several months, following deployment to low earth orbit by the Space Shuttle. Eureca will furnish to microgravity experimenters with electrical power, thermal control, and payload data management. At the end of its service period, Eureca will be retrieved by the Space Shuttle. Each Eureca will have a lifetime of ten years (or five missions). Eureca offers space industrialization experimenters the desired conditions of reduced gravity-driven convection, negligible sedimentation and hydrostatic pressure, and the possibility of containerless positioning, handling, and shaping of liquids, as well as long term exposure of biological and other substances to the space environment. O.C.

A85-49433
211 DAYS ABOARD SALYUT-7 [211 SUTOK NA BORTU 'SALIUTA-7']
M. IA. KOROLEV, ED. Moscow, Izdatel'stvo Mashinostroenie, 1983, 232 p. In Russian. No individual items are abstracted in this volume.

The flight of cosmonauts Berezovoi and Lebedev on the Salyut-7 - Soyuz T system from May to December 1982 is described. This book, liberally illustrated with color photographs, is a compilation of articles written in the popular Soviet press by scientists, cosmonauts, and journalists. B.J.

A85-49438
SCIENTIFIC FOUNDATIONS OF SPACE MANUFACTURING
V. S. AVDUEVSKII, S. D. GRISHIN, L. V. LESKOV, V. I. POLEZHAEV, and V. V. SAVICHEV (Nauchnye osnovy kosmicheskogo proizvodstva, Moscow, Izdatel'stvo Mir, 1984) Moscow, Mir Publishers, 1984, 176 p. Translation. refs

A review is given of Soviet efforts to develop platforms and techniques for materials processing in outer space. Consideration is given to the physical conditions on board a space-based materials processing platform, including the fluid mechanics of microgravity; dynamic weightlessness; and transport phenomena. Thermodynamic and kinetic aspects of phase transitions in microgravity are discussed, with emphasis given to solidification and heat transfer; the distribution of impurities; and the formation of structural defects in materials (metals, semiconductors and glasses) which are processed in space. Techniques for modeling the reactions of materials and material processes to microgravity are also described based on experimental data collected during the Soyuz and Salyut missions. I.H.

N85-22404# Joint Publications Research Service, Arlington, Va.
TASS UPDATE ON UNMANNED FLIGHT OF SALYUT-7
In its USSR Rept.: Space (JPRS-USP-85-001) p 3-10 4 Feb. 1985 Transl. into ENGLISH from Izvestiya (USSR), 20 Dec. 1984 p 1
Avail: NTIS HC A07

The relationships between man and automation in space are examined. The advantages and disadvantages of all automation, all human control, and a man machine interplay are discussed. Also considered were spacecraft control modes; automation in the first space flights; work on orbital complexed; and the flight control center. B.G.

N85-22405# Joint Publications Research Service, Arlington, Va.
LYAKHOV AND ALEKSANDROV ON 150-DAY FLIGHT
V. A. LYAKHOV and A. P. ALEKSANDROV *In its* USSR Rept.: Space (JPRS-USP-85-001) p 11-17 4 Feb. 1985 Transl. into ENGLISH from Zemlya i Vselennaya (USSR), no. 3, May-Jun. 1984 p 5-11
Avail: NTIS HC A07

During the second expedition aboard the Salyut-7 station more than 300 experiments were carried out in the fields of astronomy, geophysics, medicine, bioengineering, biology, as well as visual observations to study Earth's natural resources. Highlights of the experiments are described. B.G.

N85-22406# Joint Publications Research Service, Arlington, Va.
COMMENTS ON SALYUT-7 150-DAY FLIGHT
K. P. FEOKTISTOV and A. A. LONGOV *In its* USSR Rept.: Space (JPRS-USP-85-001) p 18-24 4 Feb. 1985 Transl. into ENGLISH from Zemlya i Vselennaya (USSR), no. 3, May-Jun. 1984 p 10-16
Avail: NTIS HC A07

Long orbital space flights require the presence of men onboard to analyze rapidly changing situations, to make unordinary decisions, to change conditions for the implementation of experiments, to regulate equipment, to intervene routinely in transpiring processes, and to carry out repair and preventive maintenance work. All problems to be solved aboard the orbital complex can be arbitrarily broken down into four groups: investigations, experiments, and tests of scientific equipment; industrial production; effects on the human body under spaceflight conditions; and improvement of space technology. The second long term expedition on Salyut-7 station provided work in all four groups. B.G.

N85-22415# Joint Publications Research Service, Arlington, Va.
LONGITUDE AND PITCH-ANGLE DISTRIBUTIONS OF STREAMS OF HIGH-ENERGY ELECTRONS UNDER EARTH'S RADIATION BELTS Abstract Only
S. A. AVERIN, A. M. GALPER, V. M. GRACHEV, V. V. DMITRENKO, V. G. KIRILLOV-UGRYUMOV, and S. Y. ULIN *In its* USSR Rept.: Space (JPRS-USP-85-001) p 37 4 Feb. 1985 Transl. into ENGLISH from Geomagnetizm i Aeronomiya (USSR), v. 24, no. 3, May-Jun. 1984 p 494-495 Original language document announced as A84-40102
Avail: NTIS HC A07

The results of measurements of fluxes of electrons with energies E sub e = 460MeV in a wide range of longitudes and pitch angles are given, together with the experimental dependences of the mean fluxes of albedo and quasi-trapped electrons (determined from the pitch-angle and longitude distributions) on the drift shell parameter L and the geomagnetic cutoff rigidity threshold. The measurements were made using the Yelena-F gamma-telescope on the Salyut-6 orbital station with definite spatial orientations of the station and instrument. The station had an orbital inclination of 51.6 deg. There were nine measurement sessions with different telescope positions relative to the station axes. On the basis of the pitch-angle distributions and results of computations of the limiting pitch angle separating electrons into albedo (having reflection points in the Northern and Southern Hemispheres below the altitude h 60 km) and quasitrapped (by the geomagnetic field (H 60 km) particles it was possible to determine the fluxes of electrons of both types. G.L.C.

N85-22440# Joint Publications Research Service, Arlington, Va.
REMOTE SENSING USED FOR STUDY OF FOREST RESOURCES
A. METALNIKOV, V. YEZHKOV, and P. MOROZ *In its* USSR Rept.: Space (JPRS-USP-85-001) p 67-72 4 Feb. 1985 Transl. into ENGLISH from Ekonomicheskaya Gaz. (USSR), no. 34, Aug. 1984 p 16
Avail: NTIS HC A07

Remote methods of probing the Earth from space have not only improved the operational efficiency and precision of work on forest management, but have also reduced the costs. The effectiveness of using space photography was demonstrated in the recording and inventory of field and soil protective planting. Ongoing changes in forest resources caused by human activity and natural factors are recorded by measurement of length, width, and areas of forests. Damage done by forest fires and changes in the condition of damaged areas over time are monitored; development of burn areas into centers of forest pathology is predicted and prevented; and steps toward economic incorporation of damaged sectors and restoration of the forests are determined. B.G.

N85-25285# Joint Publications Research Service, Arlington, Va.
HOLOGRAPHY IN SPACE Abstract Only
V. M. TUCHKEVICH, Y. P. SEMENOV, and S. B. GUREVICH *In its* USSR Rept.: Space (JPRS-USP-85-003) p 1-11 4 Mar. 1985 Transl. into ENGLISH from Zemly i Vselennaya (USSR), no. 3, May-Jun. 1984 p 17-24
Avail: NTIS HC A08/MF A01

The principles and merits of holographic methods are reviewed and the utilization of holography in experiments conducted onboard the Salyut 6 and 7 space stations is discussed. A short history of the development of the spaceborne holographic apparatus is given. The objects of the experiments included the dissolution of NaCl under weightless conditions; observation of station window microdefects; analysis of electrophoresis processes; and studies directed towards determining the quality of holographic results. M.G.

N85-25291# Joint Publications Research Service, Arlington, Va.
OBSERVATION OF POLAR AURORA FROM THE SALYUT-6 SPACE STATION DURING THE GREAT GEOMAGNETIC STORM OF 11-13 APR. 1981 Abstract Only
A. I. LAZAREV, V. V. KOVALENOK, and L. S. YEVLASHIN *In its* USSR Rept.: Space (JPRS-USP-85-003) p 16 4 Mar. 1985 Transl. into ENGLISH from Geomagnetizm i Aeronomiya (USSR), v. 24, no. 4, Jul.-Aug. 1984 p 620-624
Avail: NTIS HC A08/MF A01

The results of visual observation of auroras in the Southern Hemisphere performed by the cosmonauts of the 5th major expedition onboard the Salyut-6 space station, flying at about 350 km altitude are presented. Notes made by the cosmonauts are quoted verbatim. The observations on the 11th and 12th of April, 1981 were used to construct schematic maps showing the area of the auroras above the Southern Hemisphere. The observations allow clear determination of the geographic area and date and time of the aurora associated with the magnetic storm. Author

N85-25317# Joint Publications Research Service, Arlington, Va.
SPACE RADIATION MONITOR OBSERVATIONS FROM SALYUT-4 ORBITAL STATION Abstract Only
V. I. LYAGUSHIN, N. A. MAMONTOVA, B. M. MAKHMUDOV, M. A. SARAYEVA, P. I. SHAVRIN, and Y. Y. YUSHKOV *In its,* USSR Rept.: Space (JPRS-USP-85-003) p 36 4 Mar. 1985 Transl. into ENGLISH from Kosmicheskiye Issled. (USSR), v. 22, no. 4, Jul.-Aug. 1984 p 637-639
Avail: NTIS HC A08/MF A01

Space radiation levels were monitored with the Ryabina equipment from the Salyut-4 space station between December 1974 and July 1975; neutrons and charged particles were recorded with two energy thresholds for the detector. The reduced data from the 3,000 orbits are summarized. The charge particle count rates for the various energy levels are plotted as a function of time. It is noted that such observations, even with omnidirectional detectors, require consideration of both the trajectory and orientation of the satellite. The best observational conditions occurred during the deep solar activity minimum, which enabled an evaluation of the effect of orientation on the Ryabina detectors. All other factors (with the exception of the dependence on longitude and geomagnetic perturbations) do not play a very important part. Author

N85-25329# Joint Publications Research Service, Arlington, Va.
COSMONAUTS REPORT ON SPACE WELDING AT CONFERENCE Abstract Only
In its USSR Rept.: Space (JPRS-USP-85-003) p 90 4 Mar. 1985 Transl. into ENGLISH from Rabochaya Gaz. (USSR), 19 Oct. 1984 p 3
Avail: NTIS HC A08/MF A01

An evaluation report of a multipurpose hand welding tool for use in space was given by two cosmonauts who used the device. G.L.C.

N85-25332# Joint Publications Research Service, Arlington, Va.
DEVELOPMENT OF TV SYSTEMS FOR SPACECRAFT Abstract Only
V. KRICHEVSKIY *In its* USSR Rept.: Space (JPRS-USP-85-003) p 93 4 Mar. 1985 Transl. into ENGLISH from Izv. (USSR), 25 Oct. 1984 p 3
Avail: NTIS HC A08/MF A01

Soviet spacecraft television systems are reviewed in a historically retrospective manner, beginning with the unmanned Luna-3 mission of 1959, designed to photograph the back side of the Moon, through the Soyuz-1 mission which transmitted TV information to the Salyut-7 space station. G.L.C.

N85-25359# Joint Publications Research Service, Arlington, Va.
USE OF SPACE PHOTOGRAPHIC INFORMATION TO MAP PLANT COVER Abstract Only
T. V. VERESHCHAKA, B. V. KRASNOPEVTSEVA, and V. V. USOVA *In its* USSR Rept.: Space (JPRS-USP-85-003) p 121 4 Mar. 1985 Transl. into ENGLISH from Izv. Vysshikh Uch. Zaved.: Geod. i Aerofotosyemka (USSR), no. 4, Jul.-Aug. 1984 p 99-106 Original language document announced as A85-11815
Avail: NTIS HC A08/MF A01

The paper examines the compilation of vegetation maps on the basis of Salyut-5 remote sensing data. Also considered are methodological questions pertaining to the interpretation of images of vegetation cover in the compilation of topographic survey maps. Tables are presented, describing vegetation cover location and dynamics in various altitude zones (150 m to more than 2200 m) and the relationship with relief. B.J. (IAA)

N85-25609# Joint Publications Research Service, Arlington, Va.
MBB/ERNO'S VIEWS, FUTURE PLANS IN AEROSPACE ACTIVITIES
In its West Europe Rept.: Sci. and Technol. (JPRS-WST-84-008) p 6-7 29 Feb. 1984 Transl. into ENGLISH from Frankfurter Allgem. Zeitung (Frankfurt/Main), 20 Jan. 1984 p 15
Avail: NTIS HC A04/MF A01

MBB Erno's future plans in aerospace activities are explained. The second Spacelab is already being built in the workshops in Bremen. The payload is currently being prepared for installation in the system for the first German spacelab mission which is scheduled for December 1985. MBB/Erno is again building the first retrievable and free flying experimental platform called Eureca (European Retrievable Carrier). B.W.

N85-25618# Joint Publications Research Service, Arlington, Va.
FRG OPINION ON SPACELAB BENEFITS, SPACE STATION PARTICIPATION
B. FEUERBACHER *In its* West Europe Rept.: Sci. and Technol. (JPRS-WST-84-026) p 1-8 1 Aug. 1984 Transl. into ENGLISH from Bild der Wiss. (Stuttgart), May 1984 p 48-55
Avail: NTIS HC A04/MF A01

The scientific benefits of Spacelab are examined and documented. The historic role of spacelab in manned space flight is explored. Plans for future spacelab flights are discussed in terms of research needs. German participation in the development of a permanent space station is also discussed. Cost effectiveness is seen as a major consideration in space station development. B.W.

N85-26773# Joint Publications Research Service, Arlington, Va.
TASS REPORTS PROGRAM FOR SALYUT-7 FULLY COMPLETED Abstract only
In its USSR Rept.: Space (JPRS-USP-85-004) p 1 6 May 1985 Transl. into ENGLISH from Pravda (Moscow), 2 Mar. 1985 p 2
Avail: NTIS HC A06

The Salyut-7 scientific station was functioning in near-Earth orbit for more than 34 months. During this time three main expeditions have worked on the station for periods of 211, 150 and 237 days. In addition, there were four visiting expeditions, including two international ones with cosmonauts from France and India. For the first time a female cosmonaut, S. Ye. Savitskaya, performed work in open space. A number of complex repair and maintenance operations were performed both inside the Salyut-7 station and in open space. A significant amount of research and experientation was carried out in the interest of science and the national economy. The data obtained are being processed by institutes of the USSR Academy of Sciences. In view of the fact that the planned program of work on the Salyut-7 station was fulfilled completely, the station was deactivated and is continuing its flight in automatic mode. Author

N85-26774# Joint Publications Research Service, Arlington, Va.
COSMONAUT SAVITSKAYA SAYS MANY WOMEN IN COSMONAUT TRAINING Abstract Only
V. FARTYSHEV and S. Y. SAVITSKAYA *In its* USSR Rept.: Space (JPRS-USP-85-004) p 2 6 May 1985 Transl. into ENGLISH from Kosmolskaya Pravda (Vilnius, USSR), 22 Jan. 1985 p. 1
Avail: NTIS HC A06

Cosmonaut Svetlana Yevgen'yevba Savitskaya was interviewed in connection with the upcoming 12th World Festival of Young People and students in Moscow. Savitskaya is a member of the soviet preparatory committee for this festival. Savitskaya comments on welding and biotechnology experiments in which she took part during her second mission on board the orbiting station Salyut-7 and responds to another question about the goals of U.S. and Soviet space research. Savitskaya discussed future space flights by women. B.G.

N85-26799# Joint Publications Research Service, Arlington, Va.
GLOW OF IONOSPHERIC F-LAYER IN LINE 630 NM DETERMINED FROM PHOTOGRAPHS TAKEN ABOARD SALYUT-6 ORBITAL STATION: INTERPRETATION OF RESULTS Abstract Only
I. A. NESMYANOVICH, G. S. IVANOV-KHOLODNYY, and G. M. NIKOLSKIY *In its* USSR Rept.: Space (JPRS-USP-85-004) p 22-23 6 May 1985 Transl. into ENGLISH from Geomagn. i Aeron. (Moscow), v. 24, no. 5, Sep.-Oct. 1984 p 748-753
Avail: NTIS HC A06

Photographic observations of the second luminescent layer in the upper atmosphere made from the Salyut-6 station afforded new possibilities for studying the ionospheric F-region. It was necessary to determine whether the registered high intensities agree with data from other surface and space measurements and to ascertain why this layer was not reliably detected during other manned flights. An attempt was made to solve these problems using data published by V. V. Ryumin, et al. The Salyut-6 data were consistent with other measurements and theoretical computations. With an increase in flight altitude from 250 to 350 km the observed surface brightness at the maximum of the luminescent layer increases by a factor of 1.6. The brightness of the second layer lies near the threshold of visual registry of radiation an therefore even such an increase can favor detection of the glow. The dependence of brightness of the second layer on solar depression and geomagnetic latitude cannot be accepted. The only conclusion that can be drawn is that the maximum brightness of the second layer is observed in the tropial zone and at the near-midnight hours. Author

N85-26811# Joint Publications Research Service, Arlington, Va.
RESEARCH ON ZERO-GRAVITY BOTANY APPARATUS Abstract Only
S. LAPENIS *In its* USSR Rept.: Space (JPRS-USP-85-004) p 35 6 May 1985 Transl. into ENGLISH from Komsomolskaya Pravda (USSR), 2 Feb. 1985 p 3
Avail: NTIS HC A06

During a long flight of Soviet cosmonauts on board a Salyut station, a plant was cultivated which passed through all stages of growth. Scientists are studying effects of terrestrial gravity on the spatial orientation of plants and processes of their growth and morphogenesis, and they are developing new experimental apparatus for space stations. A unit for growing plant cultures, controlling their growth and studying their internal processes in zero gravity was fabricated. G.L.C.

N85-26812# Joint Publications Research Service, Arlington, Va.
STRUCTURAL-FUNCTIONAL CHANGES IN BACTERIAL CELLS UNDER SPACEFLIGHT CONDITIONS Abstract Only
S. N. ZALOOGUYEV, S. V. PROZOROVSKIY, L. N. KATS, F. M. KIRILLOVA, V. L. POPOV, A. F. MOROZ, N. G. ANTSIFEROVA, L. I. GLATMAN, M. P. BRAGINA, V. M. SHILOV et al. *In its* USSR Rept.: Space (JPRS-USP-85-004) p 36 6 May 1985 Transl. into ENGLISH from Dokl. Akad. Nauk SSSR (Moscow), v. 278, no. 5, Oct. 1984 p 1236-1237
Avail: NTIS HC A06

A study was made of the structure and process of toxin formation in bacteria during spaceflight in the joint Soviet-French Tsitos-2 experiment carried out aboard the Soyuz-T5-Salyut-7-Soyuz-T6 orbital complex in July 1982. The experiment was original in that it was carried out in the oribtal flight phase with bacteria cultivated in vitro, whereas earlier such experiments were with biological material which had completed flight. The studied strains were E. coli and Staphylococcus aureus (taken from a cosmonaut) and laboratory strains of E. coli and Pseudomonas aeruginosa. Technical details of the experiment are given. Study of these strains over the course of the experiment failed to reveal clearly expressed differences in the cytoplasm, but the cell walls in the space variant had thickened considerably (89 nm) in comparison with the control (28 nm). The periplasmic space had expanded due to withdrawal of the cell wall membrane from the cytoplasmic membrane. These and other data make it possible to conclude that there are no well-expressed changes in the submicroscopic organization on bacteria, other than the cell wall thickening. Author

N85-26814# Joint Publications Research Service, Arlington, Va.
CONSTRUCTION AND FUNCTIONING OF EXTENDED ORBITAL SYSTEMS Abstract Only
G. M. MOSKALENKO and A. V. ANDREYEV *In its* USSR Rept.: Space (JPRS-USP-85-004) p 57 6 May 1985 Transl. into ENGLISH from Kosmich. Issled. (Moscow), v. 22, no. 3, May - Jun. 1984 p 457-467
Avail: NTIS HC A06

An extended or elongated orbital system is presented. The concept of regular motion of an extended system is introduced and stationary and nonstationary cases of this motion are examined. The mass-geometrical characteristics of the system are computed. Rules for the construction and transformation of different systems are formulated for motion of the chain in a circular orbit with its orientation along the radius vector. The problem of system computation is separated into dynamic and constructive-geometrical parts. General laws of system deployment are established for the class of motions. Analytical formulas are derived for evaluating system parameters in different operation regimes. E.A.K.

N85-26830# Joint Publications Research Service, Arlington, Va.
FORECASTS ON LONG-RANGE DEVELOPMENT OF SPACE PROGRAMS
V. SENKEVICH *In its* USSR Rept.: Space (JPRS-USP-85-004) p 88-93 6 May 1985 Transl. into ENGLISH from Krylya Rodiny (Moscow), no. 11, Nov. 1984 p 16-17
Avail: NTIS HC A06

The long range objectives of the U.S.S.R. space program are discussed. Future research initiatives include: (1) the development of an orbital space station; (2) lunar exploration; and (3) deep space exploration. Areas of international cooperation are also discussed. B.W.

N85-27926# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Cologne (West Germany).
EUROPEAN UTILIZATION ASPECTS OF A US MANNED SPACE STATION, VOLUME 1 Final Report
Paris ESA Apr. 1983 65 p Prepared in cooperation with MBB GmbH, Bremen, West Germany, Aeritalia SpA, Turin, British Aerospace Aircraft Group, Bristol, Dornier-Werke GmbH, Friedrichshafen, West Germany, and Matra, Toulouse 2 Vol.
(Contract ESA-5243/82/F-FC(SC))
(ESA-CR(P)-1987-VOL-1) Avail: NTIS HC A04/MF A01

European payload candidates which can be beneficially supported by a manned space station (MSS) are identified. The required operational station support is assessed. Alternative approaches if no manned space station is available are discussed and the impact identified. The MSS is needed in life sciences, space technology, and materials science. The MSS needs to be completed by free flying platforms for automatic material processes, space sciences, and Earth observations. The majority of identified payload candidates are for basic research. Commercial payloads are only identified in telecommunications. Identification of commercial materials processing payloads depends on the results from Spacelab. Author (ESA)

N85-27927# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Cologne (West Germany).
EUROPEAN UTILIZATION ASPECTS OF A US MANNED SPACE STATION, VOLUME 2 Final Report
Paris ESA Apr. 1983 393 p refs Prepared in cooperation with MBB GmbH, Bremen, West Germany, Aeritalia SpA, Turin, British Aerospace Aircraft Group, Bristol, Dornier-Werke GmbH, Friedrichshafen, West Germany, and Matra, Toulouse 2 Vol.
(Contract ESA-5243/82/F-FC(SC))
(ESA-CR(P)-1987-VOL-2) Avail: NTIS HC A17/MF A01

European payload candidates which can be beneficially supported by a manned space station (MSS) are identified. The required operational space station support is assessed. Alternative approaches if no manned space station is available are discussed and the impact identified. The MSS is needed in life sciences, space technology, and materials science. The MSS need to be completed by free flying platforms for automatic material processes, space sciences, and Earth observations. The majority of identified payload candidates are for basic research. Commercial payloads are only identified in telecommunications. Identification of commercial materials processing payloads depends on the results from Spacelab. Author (ESA)

N85-27931# Maschinenfabrik Augsburg-Nuernberg A.G., Munich (West Germany).
THE ARIANE LAUNCH VEHICLE IS THE KEY OF THE EUROPEANS TO THE SPACE MARKET [DIE TRAEGERRAKETE ARIANE IST DER SCHLUESSEL DER EUROPAER ZUM WELTRAUMMARKT]
F. LAUSSERMAIR 1984 7 p In GERMAN
Avail: NTIS HC A02/MF A01

The history and commercial future of Ariane are described. Arianespace got 30 orders and 14 reservations. Ariane 4 is being developed. The heaviest Ariane 4 version represents a payload increase of 70% compared to Ariane 3. Ariane 4 is expected to be competitive in space transportation until the mid-nineties. Ariane 5 is seen as a rival to the Space Transportation System; it has to be able to bring larger and heavier payloads into low and high orbits. Cooperation with the US in the construction of a space station can open interesting transportation tasks in the low orbit for Ariane 5. Author (ESA)

N85-28886# Bundesministerium fuer Forschung und Technologie, Hamburg (West Germany).
DOCUMENTATION FOR THE WEST GERMAN FEDERAL CABINET'S SPACE POLICY DECISION [UNTERLAGEN ZUR ENTSCHEIDUNG DES BUNDESKABINETTS ZUR WELTRAUMPOLITIK]
GREGER Apr. 1985 33 p In GERMAN
Avail: NTIS HC A03/MF A01

The financial and technical contribution of the German government to the Columbus program and the HM 60/Ariane 5 program as well as the time schedule are presented. The different programs and the NASA space station are described. The importance of the NASA space station for Europe is studied in its scientific, technological, financial and political aspects.
Author (ESA)

N85-28959 Marconi Space Systems Ltd., Portsmouth (England).
SPACE STATION STUDY Final Report
Sep. 1984 90 p
(Contract A57A/1667)
(BL-6167) Avail: Issuing Activity

The benefits and disadvantages to British industry of participating in a NASA space station are discussed. The main station, free flying platforms, and transfer vehicles are described. Life science, Earth science, materials science, and astronomy applications are summarized. The power, data management, communications, and remote sensing requirements of the space station are considered. Author (ESA)

N85-28962# Joint Publications Research Service, Arlington, Va.
NEW ESA DIRECTOR ON SPACE STATION, MILITARY SPACE
C. BERTRAM, G. HAFF, and H. MICHAELS *In its* West Europe Rept.: Sci. and Technol. (JPRS-WST-84-036) p 7-18 8 Nov. 1984 Transl. into ENGLISH from Die Zeit (Hamburg), 31 Aug. 1984 p 9-11
Avail: NTIS HC A04/MF A01

Participation of ESA in the American space station program is discussed with ESA's new director. It is conceded that the growing presence of Europeans in space may cause military problems, even through the ESA's programs and the privately organized satellite shopping service Ariane-space serve exclusively for peaceful puropses. The Esa faces an important task in planning and coordinating future European Space projects. E.A.K.

N85-29087# Joint Publications Research Service, Arlington, Va.
ESA PRESENTS PLANS FOR EUROPEAN MANNED SPACE STATION
In its West Europe Rept.: Sci. and Technol. (JPRS-WST-84-022) p 4-10 2 Jul. 1984 Transl. into ENGLISH from AFP Sci. (Paris), 10 May 1984 p 23-29
Avail: NTIS HC A04/MF A01

A concept for a space station capable of meeting Europe's needs starting in 1990, which combines the principles of the Eureca automatic station and of the European space laboratory Spacelab is described. The goal of this project is to create new materials and new products in microgravity. The disadvantages and advantages associated with the space station are addressed.
B.W.

N85-29091# Joint Publications Research Service, Arlington, Va.
DFVLR OFFICIAL ON AREAS OF US-FRG SPACE STATION COOPERATION
H. SAX *In its* West Europe Rept.: Sci. and Technol. (JPRS-WST-84-031) p 8-22 11 Sep. 1984 Transl. into ENGLISH from DFVLR-Nachrichten (Cologne), Jun. 1984 p 19-25
Avail: NTIS HC A03/MF A01

Goals are stated, from the German prospective, for the proposed joint U.S.-European space station program. Topics discussed include: type of station; purpose and mission of the station; and station applications. A provisional list of missions for the station includes trials in the following fields: (1) material sciences; (2) biosciences; (3) space sciences; (4) Earth surveillance; (5) communication and navigation via satellite; and (6) astronautic technology and operational support. G.L.C.

N85-29096# Joint Publications Research Service, Arlington, Va.
NEW ESA DIRECTOR ON ARIANE, SPACE STATION, FUTURE TRENDS
In its West Europe Rept.: Sci. and Technol. (JPRS-WST-84-032) p 1-4 25 Sep. 1984 Transl. into ENGLISH from Flug Rev. (Stuttgart), Jul. 1984 p 32-33
Avail: NTIS HC A03/MF A01

An interview with the new general director of the European Space Agency (ESA) by a West Germany periodical is given. Thoughts on the policies and direction ESA will take under the new director are presented. Further development of Ariane, cooperation with NASA on the Space Station and budgeting directions are some areas explored. E.R.

N85-29110# Joint Publications Research Service, Arlington, Va.
FRG WEIGHS ESA PARTICIPATION, BUDGET ISSUES
In its West Europe Rept.: Sci. and Technol. (JPRS-WST-84-037) p 15-18 27 Nov. 1984 Transl. into ENGLISH from Handelsblatt (Duesseldorf), 10 Sep. 1984 p 10
Avail: NTIS HC A05/MF A01

Policies and expenditures for European space operations for many years to come are outlined. The Europeans must decide in the very near future whether they want to participate in the construction of the large American space station. The decision has to be a session of the ministerial council of the European Space Agency (ESA). The construction of the large rocket suited for manned space travel, the Ariane-5, has to be decided on. European finances are examined and European space expenditures are compared to the feasibility of the projects is analyzed.
E.A.K.

N85-29111# Joint Publications Research Service, Arlington, Va.
DFVLR STUDY RECOMMENDS EUROPEAN INDEPENDENCE IN SPACE SYSTEMS
In its West Europe Rept.: Sci. and Technol. (JPRS-WST-84-037) p 19-24 27 Nov. 1984 Transl. into ENGLISH from Frankfurter Z. Blick Durch die Wirtsch. (Frankfurt am Main), 27 Aug. 1984 p 3
Avail: NTIS HC A05/MF A01

The German research and development institute of air and space travel (DFVLR) recommended the construction of the European Ariane 5 booster rocket and participation in the construction of an American space station for the future development of European Space travel. The DFVLR proposes that the FRG participates in the development of serviceable platforms with manned space station elements. The development of the RM 60 rocket engine is recommended as part of the Ariane program, which will give the planned Ariane 5 rocket so much thrust that it can put a European space ferry into orbit around the Earth. The grand scenarios for European space travel which include an unmanned recovery system to supply space platforms, serviceable equatorial and polar platforms, in addition to the Ariane 5 and a European space ferry (Euro-Shuttle), are twice as high in their development costs as the other space scenarios. E.A.K.

N85-29112# Joint Publications Research Service, Arlington, Va.
ASTRONAUTICAL CONFERENCE HEARS DETAILS ON HERMES MINISHUTTLE
In its West Europe Rept.: Sci. and Technol. (JPRS-WST-84-037) p 25-26 27 Nov. 1984 Transl. into ENGLISH from AFP Sci. (Paris), 11 Oct. 1984 p 16-18
Avail: NTIS HC A05/MF A01

A description is given of the European minishuttle Hermes, currently designed by scientists and engineers at the French Nation Center for Space Studies. The Minishuttle will be able to land on any standard airport runway 3 to 3.5 km long. Design specifications and launch plants for the Minishuttle are presented. B.W.

N85-29979*# National Aeronautics and Space Administration, Washington, D.C.
INTERNATIONAL SPACE RESEARCH PERSPECTIVES OF COMMERCIALIZATION FOR GERMAN INDUSTRY
H. L. JORDAN Jul. 1985 31 p Transl. into ENGLISH of "Weltraumforschung - perspektiven der kommerziellen nutzung fur die deutsche industrie" Linder Hoehe, West Germany, 19 Oct. 1984 16 p Presented at Meeting of the Comm. for the Politics of Res. and Sci., Bonn, 19 Oct. 1984 Transl. by Scientific Translation Service, Santa Barbara, Calif. Original document prepared by DFVLR, Linder Hoeh, West Germany
(Contract NASW-4004)
(NASA-TM-77657; NAS 1.15:77657) Avail: NTIS HC A03/MF A01 CSCL 22A

A brief overview of space flight activities is presented. West German contributions to satellite mapping, communication satellites, navigation, Spacelab, diffusion under weightlessness, crystal growth in space, metal bonding, and biochemistry are described. The future of the research in the space station is analyzed. B.W.

N85-31217# Societe Nationale Industrielle Aerospatiale, Les Mureaux (France). Div. Systemes Balistiques et Spatiaux.
STUDIES TOWARD A MANNED SPACE STATION: PARTICIPATION OF EUROPEAN INDUSTRY IN NASA SPACE STATION (MSS) Final Report
Paris ESA 5 Aug. 1983 69 p refs
(Contract ESA-5307/82/F)
(SNIAS-S/DT-Y-25-212; ESA-CR(P)-2018) Avail: NTIS HC A04/MF A01

Manned space station (MSS) mission analysis and the design of a small orbital transfer vehicle for a wide range of missions (rendezvous, servicing, retrieval) called the Self-Propelled Teleoperator (SPT) are summarized. The launching of a large cryogenic orbital transfer vehicle (OTV) from the MSS: fueling, mechanical handling, integration, check-out, and flight monitoring is discussed. Space station architecture and the establishment of design driver criteria are considered. The study shows that even where European technologies are comparable to American ones, cooperation must be limited to European firms acting as subcontractors to NASA or US firms, rather than at a transnational European level. At the European level, development of SPT and other teleoperated vehicles satisfies criteria for program size; interface definition, European ability, multiplicity of participants favoring money redistribution, and compatibility of planning schedules. Commonality of mission with a European automatic platform is an advantage. Author (ESA)

N85-31223# Erno Raumfahrttechnik G.m.b.H., Bremen (West Germany). Hauptabteilung Vorprojekte und Studien.
GERMAN PAYLOADS FOR EURECA 1 Final Report, May 1983
J. BOCK, B. HAASE, J. SCHAWER, A. TEGTMEIER, and G. WIECZOREK Bonn Bundesministerium fuer Forschung und Technologie Mar. 1985 54 p In GERMAN; ENGLISH summary Sponsored by Bundesministerium fuer Forschung und Technologie
(BMFT-FB-W-85-003; ISSN-0170-1339) Avail: NTIS HC A04/MF A01; Fachinformationszentrum, Karlsruhe, West Germany DM 11.50

The EURECA 1 High Temperature Thermostat, the Zone Melting Facility, and the High Precision Thermostat (HPT) are described. Integration of the HPT in a MAUS container, thermal shielding, and vibration tests of vital experiment components (differential pressure cell) are emphasized. Author (ESA)

N85-33128# Joint Publications Research Service, Arlington, Va.
USSR REPORT: SPACE
14 Nov. 1984 157 p refs Transl. into ENGLISH from various Russian articles
(JPRS-USP-84-006) Avail: NTIS HC A08

Progress in Soviet aerospace engineering, science, and technology is reported. Topics discussed include: manned mission flights, space sciences, life sciences, space engineering, space applications, space policy and administration, and launch tables.

N85-33129# Joint Publications Research Service, Arlington, Va.
SPECIAL TOOLS USED BY COSMONAUTS IN EVA Abstract Only
A. POKROVSKIY *In its* USSR Rept.: Space (JPRS-USP-84-006) p 7 14 Nov. 1984 Transl. into ENGLISH from Pravda (Moscow), 9 Aug. 1984 p 6
Avail: NTIS HC A08

Original operations performed by cosmonauts in open space during their mission on board the orbiting station Salyut-7 are described. The preparation and methods of operations carried out by two cosmonauts during their sixth egress from the station are reported. Unique equipment, including a hand-held pneumatic press, was developed on Earth while the mission was in progress. During the open-space operation the fuel line was flattened by compressed air from the pneumatic unit. The method ensures that the line remains sealed shut for the duration of the flight. E.A.K.

N85-33131# Joint Publications Research Service, Arlington, Va.
SALYUT-7 COSMONAUTS WORK WITH RS-17 AND GSPS X-RAY TELESCOPES
A. POKROVSKIY *In its* USSR Rept.: Space (JPRS-USP-84-006) p 32-33 14 Nov. 1984 Transl. into ENGLISH from Pravda (Moscow), 21 Sep. 1984 p 6
Avail: NTIS HC A08

Two X-ray telescopes were tested aboard Salyut-7. The two instruments were the RS-17, and the GSPS. The X-ray sources, particularly in the Crab Nebulae and the Cygnus constellation, were observed spectrometrically. It is found that the two telescopes complement one another, the GSPS has high resolving power while the RS-17 receives the hard X-ray radiation. It is suggested that X-ray radiation accompanies the final stage of the evolution of certain stars and the processes which lead to the death of giant stars. E.A.K.

N85-33141# Joint Publications Research Service, Arlington, Va.
COSMONAUTS' CARDIOVASCULAR SYSTEM FUNCTION DURING LONG-TERM ORBITAL FLIGHTS ABOARD SALYUT-6 STATION
A. D. YEGOROV, O. G. ITSEKHOVSKIY, I. V. TURCHANINOVA, A. P. ALFEROVA, A. P. POLYAKOVA, and V. I. BERNADSKIY *In its* USSR Rept.: Space (JPRS-USP-84-006) p 80-88 14 Nov. 1984 refs Transl. into ENGLISH from Vestn. Akad. Med. Nauk SSSR (Moscow), no. 4, Apr. 1984 p 55-61
Avail: NTIS HC A08

The functional stage of the cardiovascular system during long term spaceflights were evaluated by means of functional tests with use of lower body negative pressure (LBNP) and graded physical loads (GPL) on a cycle ergometer. The former test simulates orthostatic factors in weightlessness and determines readiness of postural mechanisms for gravity forces. The test evaluates the work capacity of cosmonauts according to their hemodynamic reaction to a specific physical exercise. E.A.K.

N85-33321# Joint Publications Research Service, Arlington, Va.
VATRA TELVISION COMPLEX FOR SALYUT ORBITAL SPACE STATION Abstract Only
Y. G. BRATIVNK, D. P. BRILLIANTOV, and V. V. MOVCHAN *In its* USSR Rept.: Electron. and Elec. Eng. (JPRS-UEE-84-015) p 5 23 Nov. 1984 Transl. into ENGLISH from Tekhn. Kino Televideniya (Moscow), no. 6, Jun. 1984 p 3-5
Avail: NTIS HC A05/MF A01

Early spacecraft had one-way TV systems but increased information and astronaut psychological support needs in long flights, including contacts with friends and relations on the ground, led to the development of the two way Vatra system for Salyut-6 spacecraft. The system was improved during three long Salyut-6 expeditions, and the forth trip utilized a variant with an optical telecamera adaptor for observing the dark side of the Earth as well as stars and galaxies in the infrared range. The design

objectives are compactness, reliability and minimal energy consumption and mass. Silicon solar batteries are the energy source supplying around 0.7 W per square decimeter of illuminated surface. Spacecraft voltage goes from 34 to 23 V when it passes into the unilluminated zone. The complex consists of a switch unit, portable videorecorder, TV camera, monitor (with 23 cm diagonal picture tube), and acoustic system and a TV transmitter and receiver. The complex can take images and display, transmit and receive either live or on tape. It has been repeatedly tested and found adequate. Author

N85-33386# Joint Publications Research Service, Arlington, Va.
METHOD OF CONSTRUCTING FOLDING UMBRELLA-TYPE ANTENNA Abstract Only
V. I. LOMAN and M. V. GRYANIK *In its* USSR Rept.: Electron. and Elec. Eng. (JPRS-UEE-84-003) p 5 21 Mar. 1984 Transl. into ENGLISH from Izv. Vysshikh Uchebn. Zavedeniy: Radioelektron. (Kiev), v. 26, no. 8, Aug. 1983 p 77-79
Avail: NTIS HC A05/MF A01

Studies of the focusing properties of umbrella-type reflectors show that a redistribution of the field takes place towards the edges of the focal spot. This explains the poor efficiency when feed radiators with a point phase center are used in such antennas. If the reflector is configured with a shifted parabolic generatrix for the surface, and a feed irradiation system having partial phase enter in the form of a ring is used, the phase errors can be compensated for to a considerable extent. Dual-reflector antennas with an elliptical, hyperbolic or parabolic generatrix of the subdish and a shifted parabolic axis for the large reflector have an annular phase center; thus, the construction of a folding umbrella-type antenna using one of these configurations will make it possible not only to realize the advantages of these antennas, i.e., significantly less shading of the aperture by the feed radiating system, reduction of the effect of the reflector on the feed radiator and the capability of fastening the reflector directly to the feed radiator, but also substantially to enhance its efficiency through more precise matching of the shapes of the partial phase center of the feed system and the focal region of the umbrella-type reflector. B.W.

N85-33692# Joint Publications Research Service, Arlington, Va.
EFFECT OF SUBSTRATE MOISTURE ON GROWTH AND STRUCTURE OF CORN LEAF
A. F. SAFONKIN *In its* USSR Rept.: Space Biol. and Aerospace Med., Vol. 19, No. 2, Mar. - Apr. 1985 (JPRS-USB-85-004) p 140-144 12 Aug. 1985 refs Transl. into ENGLISH from Kosmich. Biol. i Aviakosmich. Med. (Moscow), v. 19, no. 2, Mar. - Apr. 1985 p 94-96
Avail: NTIS HC A07

Experiments with higher plants aboard space vehicles were conducted in instruments with artificial substrates. Normal plant growth under such conditions depends on many environmental parameters. Water is one of the principal parameters that determines many vital functions. G.L.C.

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GENERAL

Includes descriptions, analyses, trade studies, commercial opportunities, published proceedings, seminars, hearings, historical summaries, policy speeches and statements that have not previously been included.

A85-30226
STRUCTURES, STRUCTURAL DYNAMICS, AND MATERIALS CONFERENCE, 26TH, ORLANDO, FL, APRIL 15-17, 1985, TECHNICAL PAPERS. PARTS 1 & 2
Conference sponsored by AIAA, ASME, ASCE, and AHS. New York, American Institute of Aeronautics and Astronautics, 1985, Pt. 1, 859 p.; pt. 2, 762 p. For individual items see A85-30227 to A85-30405.

Among the topics discussed are sandwich core composite panels, graphite/epoxy composite plates, composite material crack growth behavior, damage tolerance analyses, computer-based structural system design and analysis methods, thermomechanical response prediction, laser irradiation of structures, the buckling behavior of structures, hybrid reinforcing fiber composite characteristics, large space structure antenna design and structural dynamics, multilevel structural optimizations, the fracture behavior of filament-wound structures, and finite element analysis methods. Also covered are metal matrix composite materials, the superplastic forming of high strength aluminum alloys, woven fabric-reinforced composite properties, structural shape optimization, thermal stresses in sandwich panels, airfoil stability and response determination, deployable space structures, space structure control actuators, the stability of flexible structures, structure-borne noise, damping synthesis for large space structures, and optimal vibration control. O.C.

A85-30388*# Columbia Univ., New York.
REVIEW OF RESEARCH ON STRUCTUREBORNE NOISE
R. VAICAITIS (Columbia University, New York, NY) and J. S. MIXSON (NASA, Langley Research Center, Hampton, VA) IN: Structures, Structural Dynamics, and Materials Conference, 26th, Orlando, FL, April 15-17, 1985, Technical Papers. Part 2 . New York, American Institute of Aeronautics and Astronautics, 1985, p. 587-601. refs
(Contract NSG-1450)
(AIAA PAPER 85-0786)

Publications on the topic of structureborne noise are reviewed. Recent accomplishments, including representative results, are presented for aircraft, rotorcraft, space structures, automotive vehicles, ship and building technology. Special attention is given to propeller-driven aircraft. This review demonstrates that substantial progress has been made in understanding the characteristics of structureborne noise. Possible future research efforts and development of technology for control of structureborne noise are discussed. Author

A85-32841
FUTURE LAUNCH SYSTEMS
R. C. PARKINSON and C. M. HEMPSELL (British Aerospace PLC, Space and Communication Div., Stevenage, Herts., England) Aerospace (UK) (ISSN 0305-0831), vol. 12, April 1985, p. 5-10.

The Ariane 5 will not furnish launch economics which surpass the Shuttle's, and will basically use technologies dating from the 1950s. It is estimated that new designs could reduce launch costs by an order of magnitude. However, since governments fund development efforts, launch vehicle designs are constrained by political vagaries. The Shuttle incorporates Space Station features because the Space Station wasn't funded at the end of the Apollo program. A Shuttle-derived HLLV would boost large payloads into LEO at a lower cost than two STS launches. Likewise, a single-stage-to-orbit (SSTO) winged successor to the Shuttle would also bring payload costs down by a factor of 10. A German design

for a reusable booster which would place 10 tons in orbit and then parachute to recovery would also provide launch economies. However, a British SSTO concept has been developed which employs airbreathing engines for the first launch phase and would reduce fuel requirements by 80 percent. It could carry 6.5-7 tons into LEO and land on a runway after a four day mission. M.S.K.

A85-32950
SPACE STATION ASSEMBLY - HOW WILL IT BE ACCOMPLISHED?
J. H. BRAHNEY Aerospace Engineering (ISSN 0736-2536), vol. 5, May 1985, p. 56-61.

The Space Station (SS) will be built in a shape and from components which will permit unlimited evolution. A utilities module containing the power supplies will be the first payload in a sequence of five to eight STS launches. Star-like, raft and racetrack configurations have been identified as possible growth patterns, the last being the only one which will not require a main load-bearing module. A large robot arm may be needed to reach all points of the SS from a pivotal position. Stability and control of the structure will be concerns as soon as construction commences. The solar panels, the need to change orbits and the need to maintain a gravity gradient orientation will all add to the chances of exciting the SS dynamically. The hinge point for designers and builders of the SS will be that the first full-scale assembly will be on-orbit, beyond the reach of ground testing facilities. M.S.K.

A85-33000
THE MANNED SPACE STATION
B. KOVIT Grumman Aerospace Horizons (ISSN 0095-7615), vol. 21, no. 1, 1985, p. 8-19.

The development and establishment of a manned space station represents the next major U.S. space program after the Space Shuttle. If all goes according to plan, the space station could be in orbit around the earth by 1992. A 'power tower' station configuration has been selected as a 'reference' design. This configuration involves a central truss structure to which various elements are attached. An eight-foot-square truss forms the backbone of a structure about 400 feet long. At its lower end, nearest the earth, are attached pressurized manned modules. These modules include two laboratory modules and two so-called 'habitat/command' modules, which provide living and working space for the projected crew of six persons. Later, the station's pressurized space would be expanded to accommodate up to 18 persons. By comparison, the Soviets will provide habitable space for 12 aboard a 300-ton station which they are expected to place in orbit. According to current plans the six U.S. astronauts will work in two teams of three persons each. A ninety-day tour of duty is considered. G.R.

A85-33073
THE SPACE STATION - A NEW FRONTIER THESIS
J. RHEA Space World (ISSN 0038-6332), vol. V-3-256, April 1985, p. 8-10, 12-14, 16, 17.

Several firm equipment, configuration and applications concepts have emerged from preliminary design studies for the Space Station (SS), although budgetary considerations have already caused the projected launch to slip from 1993 to 1995. The baseline design requires strung-together compatible modules. The SS will serve commercial, basic sciences and military needs, provide a staging area for building structures larger than transportable whole by the STS, and will have power requirements that begin at 75 kWp. Compatibility with a 10 ft diam orbital maneuvering vehicle (OMV) is required, and crew will be rotated every 90-180 days. NASA will manage the project, a departure from prime contractor practices of past large programs. The initial SS will house four persons and is to be expandable to indeterminate dimensions. Photovoltaics are foreseen as the providers of initial power supplies. M.S.K.

A85-33432#
EXTERNAL TANK LOOKS FOR A NEW LEASE ON LIFE
R. M. DAVIS (Martin Marietta Aerospace, Michoud Div., New Orleans, LA) Aerospace America (ISSN 0740-722X), vol. 23, May 1985, p. 64, 65.

The Space Shuttle's disposable External Tank (ET) comprises two tandem-mounted aluminum pressure vessels for liquid oxygen and hydrogen, connected by a structural intertank and deeply insulated to maintain cryogenic temperatures. An account is given to the weight reduction and thermal protection system improvements that have been made since the Space Shuttle became operational. Also noted are the prospects for the bearing of the ET to orbit, where it may serve as a large structure for manned and unmanned use that offers good inherent stiffness for the mounting of antennas, and which could be scavenged for construction materials that would be applied to other space structures. O.C.

A85-33734
INNER SPACE AND OUTER SPACE - SOME OBSERVATIONS ON OVERLAP
P. NUYTTEN AIAA, SAE, ASME, AIChE, and ASMA, Intersociety Conference on Environmental Systems, 14th, San Diego, CA, July 16-19, 1984. 18 p. refs
(SAE PAPER 840984)

An introduction to and brief overview of equipment and technology in current use in the field of commercial deep-sea diving is presented. It is thought that there may be some areas of applicability to the space program, and more particularly to the proposed construction of the Space Station. Author

A85-33760* *National Aeronautics and Space Administration*, Washington, D.C.
ARTIFICIAL GRAVITY STUDIES AND DESIGN CONSIDERATIONS FOR SPACE STATION CENTRIFUGES
T. W. HALSTEAD (NASA, Life Sciences Div., Washington, DC), A. H. BROWN (Pennsylvania, University, Philadelphia, PA), C. A. FULLER (California, University, Riverside, CA), and J. OYAMA (NASA, Ames Research Center, Biomedical Research Div., Moffett Field, CA) AIAA, SAE, ASME, AIChE, and ASMA, Intersociety Conference on Environmental Systems, 14th, San Diego, CA, July 16-19, 1984. 13 p. refs
(SAE PAPER 840949)

The requirements to and capabilities of a Space Station biological facility centrifuge are discussed on the basis of an assessment of the objectives and subjects of future microgravity biological experiments. It is argued that the facility should be capable of both acute and extended chronic exposure of test subjects and biological materials to altered-g loading. In addition, the experimental approaches and equipment for microgravity studies on a Space Station are outlined. Finally, the engineering requirements of such a centrifuge are examined, with consideration of radial gravity gradients, size, and physical access to animals. L.T.

A85-34150
THE BIG COMMUNICATORS
L. BLONSTEIN (British Aerospace PLC, Space and Communications Div., Stevenage, Herts., England) Spaceflight (ISSN 0038-6340), vol. 27, May 1985, p. 229-234.

Design concepts for communications satellites which will exceed 8 kW power demands in the 1990s are described. It is assumed that more usable power would be available if cooling systems were obviated by keeping the spacecraft behind a large raft of solar cell panels. The instrument body would rotate once a day, thus pointing the antennae at the earth and achieving a 2:1 weight advantage over current three-axis stabilized satellites. A dc power capacity of 4-15 kW is considered feasible, with transfer orbit being effected by power drawn from the outer layer of still-folded cells. The panel sun shields could also be deployed on either end of a three-axis satellite. Stability would be furnished by reaction wheels and, although incompletely shaded, a large surface area would remain in the panel shadows and provide sufficient heat

dissipation. Finally, mounting two 100 m antennae on simple truss structures would keep power demands on 200 W and permit stability to be tracked by tuning to a laser beam from a ground station. The new designs are predicted to lower home antenna requirements for DBS reception to 60 cm. M.S.K.

A85-34192
THE OUTLOOK FOR SPACE COMMERCIALIZATION
J. J. HAGGERTY Space World (ISSN 0038-6332), vol. V-5-257, May 1985, p. 20-25.

An evaluation is made of the current status and outlook for space commercialization in five major areas of activity. The demand for space-based communications relay has been increasing rapidly, and is being addressed by advanced technologies that allow greater numbers of transponders per satellite, more effective employment of existing wavebands, and transmissions in a new band that is not yet in use. The NASA Landsat system of earth resources remote sensing satellites will be augmented by the French-led SPOT Image Corporation. The ESA's Ariane launch vehicle is a strong competitor in NASA Space Shuttle markets for satellite launching. 'Upper stage' orbit transfer systems are under development. Studies indicate that there are about 500 materials that could be advantageously processed aboard orbiting industrial platforms, taking advantage of zero-g conditions. O.C.

A85-34214
EVOLVING GOVERNMENT POLICY EASES WAY FOR SPACE VENTURES
C. COVAULT Commercial Space (ISSN 8756-4831), vol. 1, Spring 1985, p. 14-18.

It is pointed out that the formation of a commercial space policy at both the White House and NASA has introduced greater predictability into corporate planning for space ventures. As a consequence of this development, new groups have begun to show interest in commercial space endeavors. These groups include a broader cross section of finance and lending institutions, state and local governments interested in stimulating space business in their geographical areas, and more companies with innovative ideas. According to a new analysis, gross annual revenues for all commercial space endeavors should total between $44.5 billion and $53 billion by the year 2000. The key areas of NASA policy interest for the next two years are related to centers for commercial development, technology utilization, new NASA facilities, limited seed funding, and expanded agreements. G.R.

A85-34215
INVESTORS BALANCE ENTHUSIASM FOR NEW MARKET AGAINST RISK POTENTIAL
C. A. SHIFRIN Commercial Space (ISSN 8756-4831), vol. 1, Spring 1985, p. 19-21.

Although the interest in commercial space projects is increasing, the investment community shows caution and hesitancy regarding a commitment to such projects. The caution is a result of the particular situation which exists with respect to space-related commercial projects. They require generally a large amount of capital, the potential return on investment may be years off, and the risks, compared with other potential investments, appear greater. There are, however, a number of entrepreneurial companies which are finding capital for commercial space projects. One is developing Space Shuttle upper stages and vehicles to be used to launch commercial satellites, while another is concerned with the growing of crystals in space. A third company is developing a free-flying man-tended laboratory platform to be used for materials processing and other activities. Attention is also given to a number of Fortune 500 companies which are getting involved in commercial space projects. G.R.

A85-34216
AN ASTRONAUT'S LOOK AT COMMERCIAL SPACE OPPORTUNITIES
M. COLLINS Commercial Space (ISSN 8756-4831), vol. 1, Spring 1985, p. 24-26.

The commercial opportunities provided by space are related to the unique qualities of the space environment. These qualities are discussed, taking into account weightlessness, a practically perfect vacuum, the great differences between hot and cold, the continuous supply of solar energy, the charged particles, good visibility, absence of noise, the practically infinite size of space, and the high costs of gaining access to it. These qualities make possible the production of very precise spheres for calibration purposes, and the manufacture of ultra-pure glass and other materials. The production of rare pharmaceuticals in space is likely to have an early payoff, while the production of gallium-arsenide crystals for electronic devices is also very promising. However, the great risks involved in space ventures together with long payback times and the required large investments exert a retarding influence on space commercialization. Attention is given to the role of the government in space and opportunities provided by the Space Station. G.R.

A85-34538* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
COMMERCIAL USE OF SPACE - THE SPACE BUSINESS ERA
G. D. GRIFFIN (NASA, Johnson Space Center, Houston, TX) (U.S. Space Technology Conference and Exhibition, Zurich, Switzerland, June 19-21, 1984) Space Solar Power Review (ISSN 0191-9067), vol. 5, no. 1, 1985, p. 77-82.

Progress and avenues being explored by NASA to hasten the commercialization of space are described. A task force has recommended that the effort begin at once, that bureaucratic barriers to commercial space activities be removed, and that a partnership between government and industry be seriously explored. The government role is to establish links with private industry, invest in high-leverage technologies and space facilities which will be attractive to commercial ventures, and contribute to commercial enterprises where risks are high and significant economic benefits can be foreseen. The government/industry relationship can be legally evinced by MOUs, joint endeavor agreements, technical exchange agreements and industrial guest investigator arrangements. The Space Station is the first step in that it allows Americans to live and work in space. It is expected that international participation in Space Station development and utilization will accelerate the space business era. M.S.K.

A85-34539
THE SOLAR POWER SATELLITE - A GOAL FOR THE ECONOMIC DEVELOPMENT OF SPACE
P. E. GLASER (Arthur D. Little, Inc., Cambridge, MA) (Conference on Developing Space: Our Next Frontier, Dallas, TX, June 7, 8, 1984) Space Solar Power Review (ISSN 0191-9067), vol. 5, no. 1, 1985, p. 83-90. refs

Technological advances since the original proposal for SPS stations in 1968 indicate that mainly environmental and funding concerns, rather than feasibility, are the remaining questions in any decisions to initiate an SPS project. The actual construction could commence once satellites are beaming power to one another at microwave frequencies and orbital transfer vehicles are in operation. It is suggested that the SPS be treated as a long term goal of the space program, and that technologies which will be needed to begin construction or fulfill intermediate tasks before the construction be identified and developed as part of other space activities. The Space Station is regarded as the first step in that process, to be followed by extensive on-orbit repair and manufacturing capabilities, an orbit transfer system and establishment of a permanently manned lunar base. M.S.K.

A85-36498
THE JOHNSON SPACE CENTER
C. PEEBLES Spaceflight (ISSN 0038-6340), vol. 27, June 1985, p. 266-268.

The original NASA manned space flight group was headquartered at the Langley Center, then moved to within 40 km of Houston in September 1961. Gemini 4, in June 1965, was the first mission controlled by the Johnson Center. Shuttle and mission simulators are located in Houston, as are facilities to test components for space rating and launch survival. Personnel at the Center are managing and doing the contracting for Space Station program. It is expected that the workload from the Space Station project will cause some of the Shuttle ground apparatus to be shifted to the Kennedy Space Flight Center. M.S.K.

A85-37151
NEW OPPORTUNITIES IN SPACE; PROCEEDINGS OF THE TWENTY-FIRST SPACE CONGRESS, COCOA BEACH, FL, APRIL 24-26, 1984
Congress sponsored by the Canaveral Council of Technical Societies. Cape Canaveral, FL, Canaveral Council of Technical Societies, 1984, 446 p. For individual items see A85-37152 to A85-37175.

Various papers on space technology are presented. The general topics discussed include: international aerospace programs, machines to augment man, space communications, flight and ground operations, space station technology, innovative technology applications, future space transportation and missions, STS flight experiments, and commercialization of space. The wide scope of technologies that contribute to today's successes in space and point the way to future operations are emphasized. C.D.

A85-37152* National Aeronautics and Space Administration, Washington, D.C.
SPACELAB - THE FIRST MISSION AND BEYOND
E. JAMES and J. GARNETT (NASA, Spacelab Div., Washington, DC) IN: New opportunities in space; Proceedings of the Twenty-first Space Congress, Cocoa Beach, FL, April 24-26, 1984 . Cape Canaveral, FL, Canaveral Council of Technical Societies, 1984, p. 1-1 to 1-34.

The recent successful flight of Spacelab 1, while being the culmination of over 10 years of international cooperation, is seen as just the start of a new era in manned scientific operations in orbit. This paper highlights the objectives and results of that first mission, as well as describing the international Spacelab program, its concept, and its history. Then looking to the future, the plans for utilizing Spacelab, its versatility and potential to the science community and its continuing evolution are discussed. Plans for substantially improving the cost effectiveness of Spacelab are examined including the use of dedicated discipline laboratories and small payload carriers. Finally, the paper evaluates the importance of incorporating Spacelab technology, concepts, lessons learned, and methodology into the development and utilization of an international Space Station over the next decade. Author

A85-37174* National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
CAPTURE OF UNCONTROLLED SATELLITES - A FLIGHT DEMONSTRATION
H. M. LENOX (NASA, Marshall Space Flight Center, Huntsville, AL) IN: New opportunities in space; Proceedings of the Twenty-first Space Congress, Cocoa Beach, FL, April 24-26, 1984 . Cape Canaveral, FL, Canaveral Council of Technical Societies, 1984, p. 8-15 to 8-27.

NASA is presently exploring concepts, systems, and devices for capturing uncontrolled or non-operational satellites. Understanding of this type capture involves development of requirements and options, analyses of approaches, and extensive ground simulations. The verification of an approach is expected to require flight demonstrations of the concepts and hardware to assure confidence in application. This paper addresses a flight demonstration involving the Shuttle, an Orbital Maneuvering Vehicle (OMV), a capture mechanism, and a target vehicle capable of providing characteristic motion. A mission scenario is projected which demonstrates a capture concept, mission sequencing, capture vehicle potential, and overall capture possibilities with man-in-the-loop control. The proposed demonstration is considered a stepping stone to more demanding capture requirements. On-orbit activities are deliberately constrained to existing technology and projected systems and hardware capability for the year 1990. Author

A85-37175
SPACE DEVELOPMENT - THE STRATEGIC IMPLICATIONS
J. H. SLOAN (USAF, Los Angeles Air Force Station, CA) IN: New opportunities in space; Proceedings of the Twenty-first Space Congress, Cocoa Beach, FL, April 24-26, 1984 . Cape Canaveral, FL, Canaveral Council of Technical Societies, 1984, p. 9-1 to 9-5. refs

Space Based Industries will be stimulated by the development of the Ballistic Missile Defense (BMD). The BMD will require a space logistics capability far in excess of what the Space Shuttle can provide. This increased logistics base will aid Space Based Industries to grow by providing low cost work areas, transportation, and raw supplies. In return these industries will develop manufacturing in space. This will lead to using off-earth resources, the moon and the asteroids, and eventually to the building of self-sufficient space settlements. These space settlements will in turn be of significant military importance. Author

A85-37256
HOMESTEADING THE NEW FRONTIER
T. F. ROGERS Space World (ISSN 0038-6332), vol. V-5-258, June 1985, p. 4-7.

The use of large SST external tanks as habitation modules for an expanded U.S. civilian presence in LEO is proposed. It is pointed out that these tanks could be placed in LEO (instead of being allowed to break up in the atmosphere) at relatively low cost to provide about 70,000 cu ft of pressurized space each, to be made usable by purging any remaining fuel and installing appropriate life-support systems. It is recommended that federal-government policy for making such modules available to private users be formulated by analogy to the homesteading legislation of the 19th century. Photographs of the external tanks and drawings of various design concepts for LEO spacecraft are included. T.K.

A85-37257
MANNED MANEUVERING UNIT - TAKING A LOOK BEFORE THE LEAP
G. R. GRAF Space World (ISSN 0038-6332), vol. V-5-258, June 1985, p. 9-11.

The current development status of the manned maneuvering units (MMUs) first flown on the Space Shuttle in 1984 is surveyed. The successful performance of the MMUs so far is reviewed; modifications being considered for future missions are discussed; the need for at least two (probably modified) MMUs for the Space Station is indicated; and the possible use of MMUs in a U.S./Soviet joint space-rescue demonstration (based on the 'rescue-ball' concept) is considered. T.K.

A85-37258
THE REPUBLIC OF SPACE
A. C. DANTO (Columbia University, New York, NY) Space World (ISSN 0038-6332), vol. V-5-258, June 1985, p. 12-16.

The philosophical implications of a permanent manned presence in space are explored in an essay submitted to the Office of Technology Assessment of the U.S. Congress for consideration in its review of plans for a civilian space station. The emphasis is on the intellectual and moral qualities of the carefully selected crew members; these qualities are contrasted with those of the crews involved in terrestrial exploration and settlement and compared with those of the inhabitants of philosophical utopias such as Plato's Republic or Kant's Kingdom of Ends. The costs to society of constructing a space station are justified by the combination of increased scientific knowledge and the

self-knowledge made possible by the space environment and the requirements it makes of the crews. T.K.

A85-37259
THE MYTH OF MILITARIZATION
J. E. OBERG Space World (ISSN 0038-6332), vol. V-5-258, June 1985, p. 21-24.

The role of the military establishment in the U.S. space program is surveyed from a NASA perspective, responding to claims of increasing militarization made by Soviet spokesmen or domestic critics. Topics examined include the need for NASA-DOD cooperation to avoid duplication of services; the increasing proportion of civilian Shuttle astronauts; the relatively constant proportion of military Shuttle payloads; and the ill-suitedness of the Shuttle for antisatellite, nuclear-bombing, or SDI-related missions. T.K.

A85-37271#
LAUNCH AND RETRIEVAL MANOEUVRES FOR THE AGENCY'S FREE-FLYING SPACE PLATFORM 'EURECA'
R. MUGELLESI (ESA, Orbit Attitude Div., Darmstadt, West Germany) ESA Journal (ISSN 0379-2285), vol. 9, no. 1, 1985, p. 39-48. refs

Eureca, a free-flying space platform which is to be deployed and retrieved by the Space Shuttle, is described. The various problems involved in planning Eureca's ascent and descent transfers are discussed. The in-orbit maneuvers needed to carry out the transfers, as well as the optimal initial operating altitude for Eureca, are studied. It is shown that the choice of altitude is linked to the activities to be performed during the retrieval phase, particularly with respect to the orbital node. The benefits of using the RIT-10 electric-propulsion system to control Eureca's orbit during the free-flight phase are investigated. M.D.

A85-38251
AEROSPACE TESTING SEMINAR, 8TH, LOS ANGELES, CA, MARCH 21-23, 1984, PROCEEDINGS
Seminar sponsored by the Institute of Environmental Sciences and Aerospace Corp. Mount Prospect, IL, Institute of Environmental Sciences, 1984, 233 p. For individual items see A85-38252 to A85-38270.

Aerospace testing technology issues are discussed, taking into account the simulation of external and internal electrostatic discharges at the spacecraft system test level, space vehicle thermal cycling test parameters, Space Shuttle external tank thermal protection system design verification, tailoring dynamic qualification tests for interplanetary spacecraft, and a component vibration environment predictor. Other subjects explored are related to an STS experience update, programmatic issues, economic and productivity issues, and Space Station issues for aerospace testing. Attention is given to environmental control and life support systems, the Space Station power system, a Space Station advanced development program, an evaluation of spacecraft system acceptance test effectiveness, retest considerations for space vehicles, economic considerations in selecting spacecraft quality electronic parts, programs for modernizing aerospace production, a Shuttle free flyer qualification/acceptance program, and a protoflight test program for TDRSS. G.R.

A85-38699
INTERNATIONAL SPACE LAW [MEZHDUNARODNOE KOSMICHESKOE PRAVO]
A. S. PIRADOV, I. P. BLISHCHENKO, V. S. VERESHCHETIN, and IU. M. KOLOSOV Moscow, Izdatel'stvo Mezhdunarodnye Otnosheniia, 1985, 209 p. In Russian. refs

This textbook presents a systematic exposition of the main aspects of international space law (ISL), including current problems that are being discussed in the United Nations and other international organizations. Topics discussed include the concept, nature, and basic features of ISL; the subjects and object of ISL; the legal regime of outer space, with emphasis on the legal status of astronauts and space objects; international-legal forms of cooperation in space exploration; problems related to the militarization of space; the codification and further evolution of ISL; and questions of legal responsibility. A brief history of ISL is also provided, and an appendix contains basic ISL documents. B.J.

A85-38901
SYMPOSIUM ON INDUSTRIAL ACTIVITY IN SPACE, STRESA, ITALY, MAY 2-4, 1984, PROCEEDINGS
Symposium sponsored by the European Economic Community, ESA, Aeritalia S.p.A., et al. Paris, Eurospace, 1984, 492 p. For individual items see A85-38902 to A85-38917.

European research and planning efforts for industrial and commercial activities in space are examined in reviews and reports and illustrated with graphs, diagrams, photographs, and drawings. Topics discussed include the potential of the European space industry; processes for space use; applications to glass, ceramic, optical, pharmaceutical, and biological industries; applications to metallurgy, inorganic and organic chemistry, and physics; applications to electronics and electricity; novel uses of space; European space plans; and cooperation with the U.S. Also presented are round-table discussions on legal aspects of industrial space activity and on the use of microgravity for industrial and commercial purposes. T.K.

A85-38915#
USE OF LUNAR AND SPACE MATERIALS FOR MASSIVE DEVELOPMENTS IN SPACE
G. PIGNOLET (Association Nationale Sciences Techniques Jeunesse, Ris-Orangis, Essonne, France) IN: Symposium on Industrial Activity in Space, Stresa, Italy, May 2-4, 1984, Proceedings . Paris, Eurospace, 1984, p. 369-382. refs

The further exploration, occupation, and exploitation of the solar system is discussed, with an emphasis on the potential role of Europe. An extended analogy to the discovery and development of an unexplored area on earth is employed, and the vast (solar) energy and mineral resources of the solar system are stressed. It is pointed out that much less energy is required to conduct space exploration from a space station or from the lunar surface than from the earth. A development scenario involving large space stations in LEO, construction of orbital power plants, colonization of the moon, and mining of asteroids is proposed; and the need for significant European efforts (in partnership with the U.S., USSR, and Japan) is indicated. T.K.

A85-39093
LEGAL ASPECTS OF SPACE ACTIVITIES
I. DIEDERIKS-VERSCHOOR (International Institute of Space Law, Baarn, Netherlands) (Universita di Napoli, Aeritalia S.p.A., ESA, and NASA, International Symposium on Spacelab 1 - Results, Implications and Perspectives, Naples and Capri, Italy, June 11-16, 1984) Earth-Oriented Applications of Space Technology (ISSN 0277-4488), vol. 5, no. 1-2, 1985, p. 123-127. refs

The application of international law to space activities is considered. The design of a legal apparatus to control the collection and dissemination of remote sensing data is discussed, and examples of such an apparatus in the Landsat Treaties (1982 and 1983), and the Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space are discussed. Legal problems created by the growth of technology in direct satellite telecommunications, the construction of large space structures, and solar power satellites are also considered. I.H.

A85-39251
SPACE SYSTEMS TECHNOLOGY; PROCEEDINGS OF THE AEROSPACE CONGRESS AND EXPOSITION, LONG BEACH, CA, OCTOBER 15-18, 1984
Congress and Exposition sponsored by the Society of Automotive Engineers. Warrendale, PA, Society of Automotive Engineers, Inc. (SAE SP-593), 1984, 222 p. For individual items see A85-39252 to A85-39271.
(SAE SP-593)

Various papers on space system technology are presented. The topics discussed include: gallium arsenide solar cell vapor

phase technology, liquid phase epitaxial GaAs solar cells, the San Marco Mission solar array, autonomous solar arrays for the future, application of viscous and inviscid computation methods for rocket turbopump systems, solar dynamic power for a space station, a two-phase thermal management system for the space station, and the effect of bipropellant thruster contaminant on solar array performance. Also considered are: uprated orbital maneuvering engine, pump-fed satellite delivery stage engine technology, lox/hydrocarbon propellants for space propulsion systems, refurbishment of the Space Shuttle solid rocket motor, NASA's approach to flight confidence, diagnostic needs of the Space Shuttle main engine, reusable rocket engine turbopump condition monitoring, Space Shuttle mission extension capability, advanced launch vehicles, and the Space Shuttle main engine overhaul program. C.D.

A85-39731#
ORBITAL VEHICLE TRANSPORTATION - ISSUES OF LAW AND INSURANCE
P. D. NESGOS (Johnson and Higgins, Space Systems Group, New York, NY) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 21st, Monterey, CA, July 8-10, 1985. 8 p.
(AIAA PAPER 85-1337)

It is pointed out that the introduction of vehicles operating exclusively in space presents a host of novel legal and insurance issues. This form of transportation is subject to existing space law which was established prior to the notion of routine orbital operations. Applicable are general international and national law, and more specific regulations. Attention is given to international law issues, the principal space treaties, the principle of freedom to explore space, U.S. regulation of space transportation, the liability for the conduct of orbital transportation, the management of risk by insurance, and new challenges for space insurers. G.R.

A85-39930#
COMMERCIALIZATION OF A SPACE STATION
T. J. SHESKIN (Cleveland State University, Cleveland, OH) American Society of Mechanical Engineers, Winter Annual Meeting, New Orleans, LA, Dec. 9-14, 1984. 5 p. refs
(ASME PAPER 84-WA/TS-3)

A Space Station will create new opportunities for commercial investment. This paper explores two of the most promising areas: materials processing in space, and the servicing and launching of communications satellites. Risks to commercial investors are identified. Recommendations are offered for providing incentives to private sector companies to invest in a Space Station. Author

A85-39982
COLLISION PROBABILITIES AT GEOSYNCHRONOUS ALTITUDES
M. HECHLER (ESA, European Space Operations Centre, Darmstadt, West Germany) (COSPAR, Workshops on Space Debris, Asteroids and Satellite Orbits, 4th and 13th, Graz, Austria, June 25-July 7, 1984) Advances in Space Research (ISSN 0273-1177), vol. 5, no. 2, 1985, p. 47-57. refs

A considerable collisional hazard to operational geostationary satellites is induced by a continuously increasing population of abandoned objects and related debris. During the past 5 years first measures have been taken to remove geostationary spacecraft from the geostationary altitude at the end of their operational life. Another concern is the crowding of active satellites at some preferred longitude positions. This paper analyzes the hazard due to abandoned objects and the probability of a collision between satellites maintained within the same longitudinal slot. The operational satellites are represented by their spatial probability density in the geostationary ring. A sample of orbit propagations based on a first-order perturbation theory represents the uncontrolled objects passing through the geostationary region of space. A great number of small debris particles turns out to be particularly dangerous to large operational satellites. Author

A85-41098* National Aeronautics and Space Administration, Washington, D.C.
THE US SPACE STATION PROGRAMME
J. D. HODGE (NASA, Office of Space Station, Washington, DC) (British Interplanetary Society, Space Station Symposium, London, England, Apr. 17, 1985) British Interplanetary Society, Journal (Space Stations) (ISSN 0007-084X), vol. 38, July 1985, p. 315-318.

The Manned Space Station (MSS) involves NASA, and other countries, in the operation, maintenance and expansion of a permanent space facility. The extensive use of automation and robotics will advance those fields, and experimentation will be carried out in scientific and potentially commercial projects. The MSS will provide a base for astronomical observations, spacecraft assembly, refurbishment and repair, transportation intersection, staging for interplanetary exploration, and storage. Finally, MSS operations will be performed semi-autonomously from ground control. Phase B analysis is nearing completion, and precedes hardware development. Studies are being performed on generic advanced technologies which can reliably and flexibly be incorporated into the MSS, such as attitude control and stabilization, power, thermal, environmental and life support control, auxiliary propulsion, data management, etc. Guidelines are also being formulated regarding the areas of participation by other nations. M.S.K.

A85-41427
SPACE STATION - ONE BIG STEP TOWARD DEFINITION
J. RHEA Space World (ISSN 0038-6332), vol. V-7-259, July 1985, p. 6, 7, 9, 10.

The current schedule for phase B studies on the Space Station configuration projects completed layouts by early 1986, barring delays from modifications caused by international participation. Present hardware development activities include a reexamination of the solar panels power tower. The science module definition has been honed to house a potential 321 experiments. The definition studies have resurrected the old debate regarding the necessity of humans in space, particularly since advances in microcomputer chips and AI mean that most SS functions could be automated (at first) and only periodically tended by Orbiter crew visits. NASA has received a congressional mandate to push the state of the art of AI and robotics by automating the SS as much as possible. Meanwhile, extensive human factors analyses are being performed at the Johnson Center to determine optimal controls for humans to extract information from the SS computer system. Another goal for the program will be to ensure that the SS can be safely and efficiently used by non-astronauts. M.S.K.

A85-41856
SPACE ENERGY SYMPOSIUM, 3RD, TOKYO, JAPAN, MARCH 26, 1984, SELECTED PAPERS
M. NAGAMOTO, ED. (Tokyo, University, Japan) Symposium sponsored by the University of Tokyo and Ministry of Education, Science, and Culture. Space Solar Power Review (ISSN 0191-9067), vol. 5, no. 2, 1985, 129 p. For individual items see A85-41857 to A85-41870.

Among the topics discussed are: laser propulsion tests onboard the Space Station; a theoretical and experimental study of a rectenna array for microwave power transmission; and a solar pumped laser for use on the Space Station. Consideration is also given to: cryogenic power distribution on a space-based power station; microwave energy transmission tests for use on the Space Station; a space semiconductor processing factory; and an advanced scheme of CO2 laser propulsion. A conceptual design of a solar-ray supply system; an electric propulsions test on board the Space Station; and a design concept of a offshore receiving station for collecting energy from a space-based power system are also discussed. I.H.

A85-42223
THE SPACE STATION: AN IDEA WHOSE TIME HAS COME
T. R. SIMPSON, ED. New York, IEEE Press, 1985, 314 p. No individual items are abstracted in this volume.

A general overview of the goals and technologies to be used in the assembly of the Space Station in the 1990s is presented. Among the topics addressed are: the historical background of American and Russian manned Space Station concepts; the views of key decision-makers in the Federal Government with respect to the Space Station; the capabilities and structure of various Space Station design concepts; and the long term potential of space systems to support manned spaceflight within the solar system in the 21st century. Excerpts from the major Presidential documents concerned with manned space flight over the past 24 years are provided in an appendix. I.H.

A85-42558* National Aeronautics and Space Administration, Washington, D.C.
THE NASA SPACE STATION PROGRAM PLANS
R. F. FREITAG (NASA, Office of Space Station, Washington, DC) IN: From Spacelab to Space Station; Proceedings of the Fifth Symposium, Hamburg, West Germany, October 3-5, 1984 . San Diego, CA, Univelt, Inc., 1985, p. 155-165. Previously announced in STAR as N85-26846.
(AAS PAPER 84-313)

The design of a permanently manned Space Station is discussed. The role of the Space Shuttle, planning guidelines, international cooperation, and commercial possibilities are among the topics discussed. Author

A85-42595
POTENTIAL USES OF PROBABILISTIC RISK ASSESSMENT TECHNIQUES FOR SPACE STATION DEVELOPMENT
S. Z. BRUSKE, R. E. WRIGHT (EG&G Idaho, Inc., Idaho Falls, ID), and W. D. GEASLEN (EG&G Space Systems, Titusville, FL) IN: Protecting intellectual property in space; Proceedings of the Aerospace Computer Security Conference, McLean, VA, March 20, 1985 . New York, IEEE, 1985, p. 21-29. refs
(Contract DE-AC07-76ID-01570)

It is pointed out that Probabilistic Risk Assessment (PRA) is a methodology used effectively in the nuclear power industry to determine the risk to the general public from the operation of nuclear power plants. Details regarding the application of PRA in the nuclear industry are illustrated with the aid of a simplified example. The various steps in the risk assessment process are discussed, taking into account the determination of the initiating events, aspects of event tree development, the fault tree, component failure data bases, and consequence determination. Questions regarding the application of the PRA methodology to space station computer security are also explored, giving attention to a hypothetical example to demonstrate the methodology. The purpose of the Initiating Event Logic Diagram (IELD) is to identify the threats to the space station computer security in a structured, logical manner. The Space Station Computer Security Function Event Tree is also developed. G.R.

A85-43565
SATELLITE STRUCTURE - DESIGN PRINCIPLES, TECHNOLOGIES, MATERIALS [STRUCTURE DE SATELLITES - PRINCIPES DE CONCEPTION, TECHNOLOGIES, MATERIAUX]
J.-P. GREGOIRE (Aerospatiale, Cannes, France) and C. BRAZZINI (Aerospatiale, Les Mureaux, France) Revue Francaise de Mecanique (ISSN 0373-6601), no. 2, 1985, p. 87-95. In French.

Current practices in the design and fabrication of static and moving structural elements for communications satellites are surveyed and illustrated. The requirements imposed by the space environment and the nature of satellite missions are reviewed; strategies adopted to deal with launch, apogee-motor, vibrational, and temperature-related stresses while minimizing structural mass are discussed; the environmental compatibility, mechanical properties, and dimensional stability of fiber-reinforced composites are considered; and the typical development process is demonstrated for the cases of Arabsat, TDF-1/TVSAT, and the antenna reflectors developed at Aerospatiale for use in a series of satellites. Tables of numerical data, graphs, diagrams, and drawings are provided. T.K.

A85-44248
SPACE STATION - AN INVESTMENT IN SCIENTIFIC RESEARCH
J. H. BRAHNEY Aerospace Engineering (ISSN 0736-2536), vol. 5, Aug. 1985, p. 27-31.

Space Station laboratories are to consist of five modules, a central truss structure and free flying unmanned platforms. Research in astrophysics, solar system observation, earth science, life sciences and material processing are to be conducted in the modules. Experiments in material processing will be provided with a microgravity environment where material development can be observed while imperfections due to convection and buoyancy could be nearly eliminated in the gravity free environment. Biomedical scientists will be assisted in their study of the physiological changes that occur in humans due to weightlessness and their adaptation to this environment. Biologists will be able to observe the effect of gravity on the evalutionary development of animals and plants. An adequate life support system is necessary for these experiments to occur. Information gathered from Shuttle experiments can help create a closed life support system. The selection of orbits will be determined by the type of experiments being conducted. I.F.

A85-45817* National Aeronautics and Space Administration, Washington, D.C.
SPACE - THE LONG-RANGE FUTURE
J. VON PUTTKAMER (NASA, Washington, DC) Spaceflight (ISSN 0038-6340), vol. 27, Sept.-Oct. 1985, p. 348-354. refs

The Space Shuttle/Space Transportation System (STS) provides the basis for future development toward permanent manned Space Stations, manned access to geostationary orbit (GEO), deployment of large space structures, development of closed-cycle life support systems, and the discovery of greater industrial applications in space. Research must continue in order to make an Orbital Transfer Vehicle (OTV) which would provide manned flights to GEO and the establishment of a lunar base a reality by the year 2000. Beyond the year 2000 there should be advanced complexes in low-earth orbit (LEO), permanently manned scientific and communication stations in GEO, a permanent moon base, manned expeditions to Mars, and a geosynchronous facility. These goals can be achieved through international cooperation; cooperative programs will allow for more research at a faster pace due to joint funding. These advances could lead to improvements in the quality of life on earth and make comfortable space life a reality. I.F.

A85-47039*# National Aeronautics and Space Administration, Washington, D.C.
THE ISSUE IS LEADERSHIP
J. M. BEGGS (NASA, Washington, DC) Aerospace America (ISSN 0740-722X), vol. 23, Sept. 1985, p. 44-47.

Four NASA Phase B centers (NASA-Johnson, NASA-Marshall, NASA-Goddard, and NASA-Lewis) are responsible for construction, assembly, servicing, habitat, and other particular tasks and functions of the Space Station. The project has been joined by the aerospace programs of Canada, Japan, and the European Space Agency, ensuring technological and financial support, and cooperative use by the participants. Some of the future uses of the Space Station include biomedical research and applications; experiments in solar-terrestrial physics and astronomy; building, maintenance, and launching of space instruments and planetary missions; manufacturing and processing of materials that call for the conditions of microgravity and weightlessness; supporting communication operations; and improving earth and atmospheric observations. The political significance of the Space Station as a symbol of leadership and of friendly cooperation is noted. I.S.

A85-47041*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
A HOME AWAY FROM HOME
L. E. POWELL (NASA, Marshall Space Flight Center, Huntsville, AL), R. W. HAGER (Boeing Aerospace Co., Seattle, WA), and J. W. MCCOWN (Martin Marietta Aerospace, Denver, CO) Aerospace America (ISSN 0740-722X), vol. 23, Sept. 1985, p. 56, 57.

The role of the NASA-Marshall center in the development of the Space Station is discussed. The tasks of the center include the development of the life-support system; the design of the common module, which will form the basis for all pressurized Space Station modules; the design and outfit of a common module for the Material and Technology Laboratory (MTL) and logistics use; accommodations for operations of the Orbit Maneuvering Vehicle (OMV) and the Orbit Transfer Vehicle (OTV); and the Space Station propulsion system. A description of functions and design is given for each system, with particular emphasis on the goals of safety, efficiency, automation, and cost effectiveness. I.S.

A85-47047
NASA APPROVES FLY-NOW, PAY-LATER PLANS FOR ORBITING INDUSTRIAL FACILITY
C. COVAULT Aviation Week and Space Technology (ISSN 0005-2175), vol. 123, Aug. 26, 1985, p. 16, 17.

In a continuing effort to foster the commercialization of space, NASA has entered into an agreement with Space Industries, Inc. to furnish that company with two STS launches which will be paid for in the form of 12 percent of the revenues from the first five years of operation. The payload will be a Shuttle-tended unmanned module for materials processing. NASA also plans to benefit from access to the module and docking facility technologies which will be developed by the commercial organization. This will avoid in-house development costs for NASA. The first module will be 35 ft long and 14.5 ft wide and will cost from $250-500 million to develop. The initial launch is scheduled for 1992. Module power will be furnished by 100-ft long solar cell masts rated at 12 kW. The orbit will be selected to allow operations in concert with the Space Station orbit, thereby facilitating Orbiter visits. M.S.K.

A85-49439
SPACEFARERS OF THE '80S AND '90S: THE NEXT THOUSAND PEOPLE IN SPACE
A. R. OBERG New York, Columbia University Press, 1985, 248 p. refs

The experience of space travel today and in years to come is addressed. An astronaut's life from launch to landing is covered, including the experience of weightlessness, the performance of experiments and space walks, and the spectacular views of earth. NASA's selection procedures for pilots and mission specialists, the exhaustive training for upcoming missions, and the long-term effects of space on the human body are covered. The selection of scientists, foreigners, commercial engineers, and fine arts people is also discussed. The people who fly Department of Defense missions are examined, and the first women, blacks, hispanics, and Asian-Americans to become astronauts are profiled. Problems and opportunities that may occur aboard space stations and interplanetary missions are examined. C.D.

A85-50055
LEGAL ISSUES OF MANNED ORBITING SPACE STATIONS
A. GORBIEL (Lodz, Uniwersytet, Poland) Postepy Astronautyki (ISSN 0373-5982), vol. 18, no. 1-2, 1985, p. 7-24. refs

A necessity is postulated for negotiating a special international agreement, in the framework of the United Nations, addressing a number of detailed legal issues connected with the use of orbiting space stations. The topics to be considered in such a document are investigated, and the views advanced in the space law literature concerning the international legal specificity of the manned space stations are analyzed. Questions of jurisdiction concerning the space stations are examined, in particular the registration of a station constructed from two or more parts launched separately, and assembled later in space. The need for precise treaty regulations concerning the limits of authority of the station commander and the general relationships among the station personnel is emphasized. Finally, the problems concerning the personnel manning the space stations that belong to international organizations are discussed. I.S.

N85-22373*# National Aeronautics and Space Administration, Washington, D.C.
AEROSPACE SAFETY ADVISORY PANEL Annual Report, covering calendar year 1984
Jan. 1985 80 p
(NASA-TM-87426; NAS 1.15:87426) Avail: NTIS HC A05/MF A01 CSCL 13L

The following areas of NASA's responsibilities are examined: (1) the Space Transportation System (STS) operations and evolving program elements; (2) establishment of the Space Station program organization and issuance of requests for proposals to the aerospace industry; and (3) NASA's aircraft operations, including research and development flight programs for two advanced X-type aircraft. B.G.

N85-22453# Joint Publications Research Service, Arlington, Va.
FEOKTISTOV ARGUES AGAINST U.S. SPACE SHUTTLE DESIGN CONCEPT
K. P. FEOKTISTOV *In its* USSR Rept.: Space (JPRS-USP-85-001) p 95-99 4 Feb. 1985 Transl. into ENGLISH from Sotsialisticheskaya Ind. (USSR), 22 Nov. 1984 p 4
Avail: NTIS HC A07

The advantages and disadvantages of the U.S. Space Shuttle design concept are discussed. Topics include cost effectiveness, spacecraft launching, spacecraft landing, orbital servicing, stage separation, maneuverability, and military technology. B.G.

N85-22454# Joint Publications Research Service, Arlington, Va.
FEOKTISTOV DISCUSSES NEED FOR SPACE COLONIZATION
K. P. FEOKTISTOV *In its* USSR Rept.: Space (JPRS-USP-85-001) p 100-103 4 Feb. 1985 Transl. into ENGLISH from Sotsialisticheskaya Ind. (USSR), 23 Nov. 1984 p 4
Avail: NTIS HC A07

Four basic arguments (energy, population, cataclyms, and natural resources) that are advanced by advocates of settling in space are examined. These arguments are then contrasted with the technical assessment of the present achievements. There is no doubt that sooner or later, man will build large objects in space for the purpose of solving various scientific and applied problems. Undoubtedly these will be of great assistance in the solution by mankind of its own terrestrial problems, but whether or not they become the basic place and means for the development of terrestrial civilization remains to be seen. B.G.

N85-22459*# Boeing Aerospace Co., Huntsville, Ala.
SPACE STATION SYSTEMS TECHNOLOGY STUDY (ADD-ON TASK). VOLUME 1: EXECUTIVE SUMMARY Final Report
Feb. 1985 105 p Prepared in cooperation with Spectra Research Systems, Inc., Huntsville, Ala. 3 Vol.
(Contract NAS8-34893)
(NASA-CR-171415; NAS 1.26:171415; D483-10012-1) Avail: NTIS HC A06/MF A01 CSCL 22B

System concepts were characterized in order to define cost versus benefits for autonomous functional control and for controls and displays for OMV, OTV, and spacecraft servicing and operation. The attitude control topic focused on characterizing the Space Station attitude control problem through simulation of control system responses to structural disturbances. The first two topics, mentioned above, focused on specific technology items that require advancement in order to support an early 1990s initial launch of a Space Station, while the attitude control study was an exploration of the capability of conventional controller techniques. G.L.C.

N85-22471*# National Aeronautics and Space Administration, Washington, D.C.
SPACE STATION TECHNOLOGY PLANNING
R. E. SMYLIE *In* NASA. Lewis Research Center Spacecraft Environ. Interactions Technol., 1983 p 1-8 Mar. 1985
Avail: NTIS HC A99/MF E03 CSCL 22B

Technological requirements for Space Station design were discussed. The requirements are discussed in relation to the following areas: high voltage arrays; environmental interactions; energy management; power supplies; architecture; and modularity. B.G.

N85-23813*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
LARGE SPACE ANTENNA SYSTEMS TECHNOLOGY, 1984
W. J. BOYER, comp. Apr. 1985 466 p refs Conf. held in Hampton, Va., 4-6 Dec. 1984 2 Vol.
(NASA-CP-2368-PT-1; L-15950-PT-1; NAS 1.55:2368-PT-1)
Avail: NTIS HC A20/MF A01 CSCL 22B

Papers are presented which provide a comprehensive review of space missions requiring large antenna systems and of the status of key technologies required to enable these missions. Topic areas include mission applications for large space antenna systems, large space antenna structural systems, materials and structures technology, structural dynamics and control technology, electromagnetics technology, large space antenna systems and the space station, and flight test and evaluation.

N85-23823*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
LDR SYSTEM CONCEPTS AND TECHNOLOGY
B. PITTMAN *In* NASA. Langley Research Center Large Space Antenna Systems Technol., 1984 p 127-138 Apr. 1985
Avail: NTIS HC A20/MF A01 CSCL 03A

The Large Deployable Reflector is a 20 meter diameter infrared/submillimeter telescope planned for the late 1990's. The Astronomy Survey Committee of the National Academy of Sciences (Field Committee) recommended LDR as one of the two space based observatories that should start development in the 80's. LDR's large aperture will give it unequaled resolution in the wavelength range from 30 to 1000 microns. To meet LDR performance goals will call for advances in several technology disciplines including: optics, controls, thermal control, detectors, cryogenic cooling, and large space structures. B.G.

N85-23826*# Martin Marietta Aerospace, Denver, Colo.
BOX TRUSS DEVELOPMENT AND ITS APPLICATION
J. V. COYNER *In* NASA. Langley Research Center Large Space Antenna Systems Technol., 1984 p 213-236 Apr. 1985
Avail: NTIS HC A20/MF A01 CSCL 22B

Since 1977, Martin Marietta Denver Aerospace has aggressively pursued development of deployable structural systems applicable to a wide variety of Shuttle-transportable large space system requirements. This effort has focused on the deployable box truss, mechanisms and materials development, mesh reflector design and fabrication, gate frame truss design and fabrication, and offset-fed antenna design and analysis. The activities discussed are: box truss design; metal matrix composites; precision joints; enhanced passive damping design; mesh reflector development; gate frame truss for solar arrays; 15-meter spinning radio meter; and 60 x 120 meter push broom antenna. B.G.

N85-23840*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
LARGE SPACE ANTENNA SYSTEMS TECHNOLOGY, 1984
W. J. BOYER, comp. Apr. 1985 484 p refs Conf. held in Hampton, Va., 4-6 Dec. 1984 2 Vol.
(NASA-CP-2368-PT-2; L-15950-PT-2; NAS 1.55:2368-PT-2)
Avail: NTIS HC A21/MF A01 CSCL 22B

Mission applications for large space antenna systems; large space antenna structural systems; materials and structures technology; structural dynamics and control technology, electromagnetics technology, large space antenna systems and the Space Station; and flight test and evaluation were examined.

N85-24735*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
NASA PLANS FOR A SPACE STATION
C. COVINGTON *In its* Food Serv. and Nutr. for the Space Shuttle p 12-15 Apr. 1985
Avail: NTIS HC A05/MF A01 CSCL 06H

The rationale for developing a space station is discussed. It is envisioned as a multipurpose facility which can serve a wide range of scientific and technology development activities. Alternative approaches to the space station are also considered. Planning and engineering guidelines are developed. The commercialization of the space station is outlined. E.R.

N85-24994*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
THE IMPACT OF SCIENCE ON SOCIETY
J. BURKE, J. BERGMAN, and I. ASIMOV 1985 98 p Lectures held in Williamsburg, Va., 1983
(NASA-SP-482; L-15858; NAS 1.21:482; LC-84-14159) Avail: NTIS HC A05/MF A01; SOD HC $4.50 as SN033-000-00943-7 CSCL 05K

Four speeches delivered as part of a public lecture series to assess the impact of science on society are presented. The computerization of society, space exploration and habitation, the mechanisms of technological change, and cultural responses are addressed.

N85-24998*# Asimov (Isaac), Boston, Mass.
OUR FUTURE IN THE COSMOS: SPACE
I. ASIMOV *In* NASA. Langley Research Center The Impact of Sci. on Soc. p 77-96 1985
Avail: NTIS HC A05/MF A01; SOD HC $4.50 as SN033-000-00943-7 CSCL 05K

The possibility and consequences of the extension of human society into space are addressed. The establishment of space colonies, orbital power plants and factories, and space exploration are discussed. The necessity of world cooperation to realize such projects and the development of a global space-centered society are considered. M.G.

N85-25277* National Aeronautics and Space Administration, Washington, D.C.
TECHNOLOGY FOR LARGE SPACE SYSTEMS: A BIBLIOGRAPHY WITH INDEXES, SUPPLEMENT 11
Jan. 1985 142 p
(NASA-SP-7046(11); NAS 1.21:7046(11)) Avail: NTIS HC $14.50 CSCL 22A

This bibliography contains 539 abstracts of reports, articles and other documents introduced into the NASA scientific and technical information system between January 1, 1984 and December 31, 1984. Abstracts are arranged in the following categories: systems; analysis and design techniques; structural concepts; structural and thermal analysis; structural dynamics and control; electronics; advanced materials; assembly concepts; propulsion; and miscellaneous. Subject, personal author, corporate source, contract number, report number, and accession number indexes are listed. M.G.

N85-25279*# Boeing Aerospace Co., Seattle, Wash.
SPACE STATION SYSTEMS TECHNOLOGY STUDY (ADD-ON TASK). VOLUME 2: TRADE STUDY AND TECHNOLOGY SELECTION Final Technical Report
Feb. 1985 181 p refs
(Contract NAS8-34893)
(NASA-CR-171416; NAS 1.26:171416; D483-10012-2) Avail: NTIS HC A09/MF A01 CSCL 22A

The current Space Station Systems Technology Study add on task was an outgrowth of the Advanced Platform Systems Technology Study (APSTS) that was completed in April 1983 and the subsequent Space Station System Technology Study completed

in April 1984. The first APSTS proceeded from the identification of 106 technology topics to the selection of five for detailed trade studies. During the advanced platform study, the technical issues and options were evaluated through detailed trade processes, individual consideration was given to costs and benefits for the technologies identified for advancement, and advancement plans were developed. An approach similar to that was used in the subsequent study, with emphasis on system definition in four specific technology areas to facilitate a more in depth analysis of technology issues. G.L.C.

N85-25280*# Boeing Aerospace Co., Seattle, Wash.
SPACE STATION SYSTEMS TECHNOLOGY STUDY (ADD-ON TASK). VOLUME 3: TECHNOLOGY ADVANCEMENT PROGRAM PLAN Final Report
Feb. 1985 61 p
(Contract NAS8-34893)
(NASA-CR-171417; NAS 1.26:171417; D483-10012-3) Avail: NTIS HC A04/MF A01 CSCL 22A

Program plans are given for an integrating controller for space station autonomy as well as for controls and displays. The technical approach, facility requirements and candidate facilities, development schedules, and resource requirements estimates are given. A.R.H.

N85-26020# National Oceanic and Atmospheric Administration, Washington, D. C. Environmental Satellite, Data and Information Service.
NOAA SATELLITE OPERATIONS: PROGRAMS BRIEFING
Mar. 1985 269 p
Avail: NTIS HC A12/MF A01

The National Environmental Satellite, Data, and Information Service manages U.S. civil operational Earth-observing satellite systems as well as global data bases for meteorology, oceanography, solid-Earth geophysics, and solar-terrestrial sciences. The satellites including their sensors, data, and products and their communication and relay functions are described. Domestic and international distribution of the data, and interactions with international weather satellites are examined. The NOAA concept of a polar platform for the space station complex is presented as well as a review of satellites from 1960 to 1985. A.R.H.

N85-26440*# National Aeronautics and Space Administration, Washington, D.C.
THE 1985 LONG-RANGE PROGRAM PLAN
1984 247 p refs
(NASA-TM-87464; NAS 1.15:87464) Avail: NTIS HC A11/MF A01 CSCL 05A

That continual evolution of NASA's research and development, is reflected in the missions, goals, and objectives planned for FY1985 and later years, in accordance with the responsibilities by the National Aeronautics and Space Act of 1958, as amended. New starts for the next ten years and space program activities to year 2000 are highlighted including space science and applications, space flight, space station, space tracking and data systems, and space research and technology. Space programs for the early 21st century and aeronautics programs up to and beyond the year 2000 are also covered. A.R.H.

N85-26610*# National Academy of Sciences - National Research Council, Washington, D. C. Commission on Engineering and Technical Systems.
ACTIVITIES OF THE AERONAUTICS AND SPACE ENGINEERING BOARD Summary Report, 1 Jan. - 31 Mar. 1985
Apr. 1985 13 p
(Contract NASW-4003; NASW-3455)
(NASA-CR-175825; NAS 1.26:175825) Avail: NTIS HC A02/MF A01 CSCL 01B

A summary of activities of the Aeronautics and Space Engineering Board for the period January 1, 1985 to March 31, 1985 is given. Information is given on Space Technology Research activities. R.J.F.

N85-26844*# Rockwell International Corp., Seal Beach, Calif. Satellite Systems Div.
A STUDY OF SPACERAFT TECHNOLOGY AND DESIGN CONCEPTS, VOLUME 1 Final Report
F. A. ZYLIUS 5 Mar. 1985 218 p 2 Vol.
(Contract NAS1-17758)
(NASA-CR-172579-VOL-1; NAS 1.26:172579-VOL-1; SSD-85-0012-3-VOL-1) Avail: NTIS HC A10/MF A01 CSCL 22B

Concepts for advancing the state of the art in the design of unmanned spacecraft, the requirements that gave rise to its configuration, and the programs of technology that are suggested as leading to its eventual development are examined. Particular technology issues discussed include: structures and materials; thermal control; propulsion; electrical power; communications; data management; and guidance, navigation, and control. A.R.H.

N85-26846*# National Aeronautics and Space Administration, Washington, D.C.
THE NASA SPACE STATION PROGRAM PLANS
R. F. FREITAG Oct. 1984 12 p Presented at the 5th DGLR/A.A.S./AIAA Symp., Hamburg, 3-5 Oct. 1984
(NASA-TM-87474; NAS 1.15:87474) Avail: NTIS HC A02/MF A01 CSCL 22B

The design of a permanently manned space station is discussed. The role of the space shuttle, planning guidelines, international cooperation, and commercial possibilities are among the topics discussed. R.J.F.

N85-26847*# National Aeronautics and Space Administration, Washington, D.C.
SPACESTATION: THE NEXT LOGICAL STEP
1985 55 p Original contains color illustrations
(NASA-EP-213; NAS 1.19:213) Avail: NTIS MF A01; SOD HC CSCL 22B

The concept of a U.S. space station is discussed. The design, how it will work, space laboratory functions, commerce in space, and international cooperation are discussed. R.J.F.

N85-26851*# National Academy of Sciences - National Research Council, Washington, D. C. Committee on Space Station Engineering and Technology Development.
SPACE STATION ENGINEERING AND TECHNOLOGY DEVELOPMENT
1985 136 p refs Presented at Panel on Maintainability, Huntsville, Ala., 20-21 Mar. 1985
(Contract NASW-4003)
(NASA-CR-175806; NAS 1.26:175806) Avail: NTIS HC A07/MF A01 CSCL 22B

The evolving space station program will be examined through a series of more specific studies: maintainability; research and technology in space; solar thermodynamics research and technology; program performance; onboard command and control; and research and technology road maps. The purpose is to provide comments on approaches to long-term, reliable operation at low cost in terms of funds and crew time. B.G.

N85-27925# Los Alamos Scientific Lab., N. Mex. Earth and Space Science Div.
HISTORICAL PERSPECTIVE ON THE MOON BASE: THE BRITISH PERSPECTIVE
E. M. JONES and B. R. FINNEY (Hawaii Univ., Honolulu) 1984 12 p refs Presented at Lunar Base and Space Activities of the 21st Century, Washington, D.C., 29 Oct. 1984
(Contract W-7405-ENG-36)
(DE85-005905; LA-UR-85-52; CONF-8410230-8) Avail: NTIS HC A02/MF A01

Among the many historical episodes that have relevance to the establishment of a human base, the voyages of Captain Cook, and the founding of Britain's Botany Bay colony in Australia seems

particularly appropriate. The process resulting in the selection of Cook rewards study, as do his relations with the Admiralty, with the scientific establishment and with the scientists who accompanied him. Britain's tight control of the Botany Bay settlement and its unwillingness to promote early self-sufficiency may have delayed the time when Australia became self-supporting. Structuring the lunar base to offer opportunities for private initiatives may hasten the day when it becomes a self-supporting settlement rather than an externally supported scientific base on an Antartic model. DOE

N85-27928# Erno Raumfahrttechnik G.m.b.H., Bremen (West Germany).
IN ORBIT INFRASTRUCTURE. VOLUME 1: EXECUTIVE SUMMARY
Paris ESA Jul. 1984 80 p
(Contract ESA-5602/83/F-FC(SC))
(RX011-002/84-VOL-1; ESA-CR(P)-2002-VOL-1) Avail: NTIS HC A05/MF A01

Based on the identified and projected European mission needs for Earth observation, telecommunications, space processing and scientific missions, mission requirements and in-orbit infrastructure (IOI) element function performances were established. Orbit change, rendezvous and docking, telemanipulator operations, automatic sample exchange, and automatic re-entry elements are applicable for the servicing equipment of a materials processing space platform, the orbital transfer and servicing system, and the re-entry vehicle (REV). Economic and technical arguments favor manned elements (STS) for launch/servicing/payload exchange/recovery for initial material processing missions in a 500 km/28.5 deg orbit. The introduction of Ariane 5 and REV gives Europe an independent servicing capability with similar launch costs but with higher reliance on automatic systems for rendezvous docking/servicing/payload exchange/recovery. Operational missions using Hermes, although not so economically attractive, provide Europe with an independent manned capacity. Author (ESA)

N85-28956# Societe Nationale Industrielle Aerospatiale, Les Mureaux (France). Div. Systemes Balistiques et Spatiaux.
IN ORBIT INFRASTRUCTURE Final Report
J. LACAZE 22 Jun. 1983 27 p
(Contract ESA-5163/82)
(SNIAS-S/DT-24-996; ESA-CR(P)-1984) Avail: NTIS HC A03/MF A01

A systematic approach to space activity by using a standardized automated multipurpose system of transportation and accomodation to, in, and from orbit, called In-Orbit Infrastructure (IOI) is discussed. The IOI needs of commercial space platforms for Earth observations, telecommunication, and space processing are identified. Rendezvous and docking, robotics, re-entry, and operational aspects are considered. A modular logistics and resupply vehicle is defined. An IOI implementation scenario is outlined. Author (ESA)

N85-28966# MATRA Espace, Paris-Velizy (France).
IN ORBIT INFRASTRUCTURE Final Report
P. MOLETTE, C. COUGNET, J. L. LACOMBE, P. SHARP (Erno Raumfahrttechnik GmbH), W. KLEINAU (MBB), J. FAVE (ONERA), H. FRANCOIS (Dornier-Werke GmbH), R. C. PARKINSON (BAE), and E. TURCI (Aeritalia) 18 Mar. 1983 93 p
(Contract ESA-5164/82-F-FC(SC))
(DM-51/CC-FL-044-83; ESA-CR(P)-1986) Avail: NTIS HC A05/MF A01

The review of potential European mission trends through the next two decades shows an evolution of the relevant two space segment towards heavier and larger spacecraft. The analysis of the future commercial missions, indicates that their implementation in space, their operational utilization and possibly their maintenance in orbit will require a common in orbit infrastructure. A system of transportation and accommodation to, in and from orbit, called In-Orbit Infrastructure (IOI) is discussed. The IOI needs of commercial space platforms for Earth observations, telecommunication and space processing are examined. B.W.

N85-29567*# McDonnell Aircraft Co., St. Louis, Mo.
CUSTOMER AND MISSION INFLUENCE ON SPACE STATION ARCHITECTURE
F. C. RUNGE *In* NASA. Ames Research Center Proc. of the Seminar on Space Station Human Productivity 17 p Mar. 1985
Avail: NTIS HC A99/MF E03 CSCL 05H

Overall Space Station architecture is presented in schematic outlines and plans. How the customer and mission needs influence this design is studied. The uses, occupants, activities, interfaces, utilities, locomotion, environments, and technological costs are all factors which influence the architecture. User and system functions are profiled, interfaces are characterized and functions are grouped. These lead to packaging of functions into modules and the design of system and user accommodations. E.R.

N85-29988*# Wyle Labs., Inc., Huntsville, Ala. Scientific Services and Systems Group.
COMMERCE LAB: MISSION ANALYSIS PAYLOAD INTEGRATION STUDY. APPENDIX A: DATA BASES Final Report
Jul. 1985 279 p refs
(Contract NAS8-36109)
(NASA-CR-176016; NAS 1.26:176016; P-11-84-33-APP-A) Avail: NTIS HC A13/MF A01 CSCL 22A

The development of Commerce Lab is detailed. Its objectives are to support the space program in these areas: (1) the expedition of space commercialization; (2) the advancement of microgravity science and applications; and (3) as a precursor to future missions in the space program. Ways and means of involving private industry and academia in this commercialization is outlined. E.R.

N85-30585# Joint Publications Research Service, Arlington, Va.
COSMONAUTS' POSTURAL REACTIONS AFTER LONG-TERM MISSIONS ABOARD SALYUT-6 ORBITAL STATION
V. V. KALINICHENKO and A. F. ZHERNAVKOV *In its* USSR Rept.: Space Biol. and Aerospace Med., Vol. 18, No. 5, Sep.-Oct. 1984 p 9-13 20 Nov. 1984 refs Transl. into ENGLISH from Kosmich. Biol. i Aviakosmich. Med. (Moscow), v. 18, no. 5, Sep.-Oct. 1984 p 7-10
Avail: NTIS HC A08

Tilt tests were used to study changes in cardiovascular responses to ortho- and antiorthostasis of four cosmonauts after their 96- and 140-day flights onboard Salyut-6. Preflight the cosmonauts were exposed to head-up and head-down tests in order to facilitate their readaptation to weightlessness. Postflight all cosmonauts exhibited a better cardiovascular capability to counteract cranial blood redistribution during antiorthostatic tilt tests. This can be considered as a result of their adaptation to weightlessness. After flight every crewmember showed a significant decrease of orthostatic tolerance. One of the factors responsible for the lower orthostatic tolerance is assumed to be inactivity of the vascular tone mechanisms. It is suggested that their better stimulation before reentry may improve the efficacy of countermeasures against postflight orthostatic disorders. Author

N85-30963*# Hudson Inst., Inc., Indianapolis, Ind.
SPACE VENTURES AND SOCIETY LONG-TERM PERSPECTIVES Final Report
W. M. BROWN 31 May 1985 189 p refs
(Contract NASW-3724)
(NASA-CR-176012; NAS 1.26:176012; HI-3731/2-RR) Avail: NTIS HC A09/MF A01 CSCL 05A

A futuristic evaluation of mankind's potential long term future in space is presented. Progress in space will not be inhibited by shortages of the Earth's physical resources, since long term economic growth will be focused on ways to constrain industrial productivity by changing social values, management styles, or government competence. Future technological progress is likely to accelerate with an emphasis on international cooperation, making possible such large joint projects as lunar colonies or space stations

on Mars. The long term future in space looks exceedingly bright even in relatively pessimistic scenarios. The principal driving forces will be technological progress, commercial and public-oriented satellites, space industrialization, space travel, and eventually space colonization. F.M.R.

N85-31146*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
SPACE STATION REFERENCE CONFIGURATION DESCRIPTION
Aug. 1984 798 p refs
(NASA-TM-87493; JSC-19989; NAS 1.15:87493) Avail: NTIS HC A99/MF E03 CSCL 22B

The data generated by the Space Station Program Skunk Works over a period of 4 months which supports the definition of a Space Station reference configuration is documented. The data were generated to meet these objectives: (1) provide a focal point for the definition and assessment of program requirements; (2) establish a basis for estimating program cost; and (3) define a reference configuration in sufficient detail to allow its inclusion in the definition phase Request for Proposal (RFP). G.L.C.

N85-31149*# National Aeronautics and Space Administration, Washington, D.C.
NASA SPACE CONTROLS RESEARCH AND TECHNOLOGY PROGRAM
D. E. MCIVER and R. W. KEY *In* JPL Proc. of the Workshop on Identification and Control of Flexible Space Struct., Vol. 1 p 1-11 1 Apr. 1985
Avail: NTIS HC A20/MF A01 CSCL 05A

The NASA technological organization is outlined. The Office of Aeronautics and Space Technology (OAST) is one of the four major technical offices that comprise NASA. The Office of Space Science and Applications administers programs directed towards using space-based or related techniques to further understanding of the total universe and to apply that understanding to practical applications in such areas as Astrophysics, Solar System exploration, Earth Sciences, Life Sciences, Communications and Information Systems. The Office of Space Flight administers the programs for all U.S. civil launch capability, plus Spacelab development and operations. The Office of Space Tracking & Data Systems administers the programs that operate and maintain a world-wide network of facilities for data acquisition, processing, and ground to spacecraft communications for all NASA missions. The OAST has primary responsibility within NASA for conducting space research and technology development to support commercial and military as well as NASA space interests. E.A.K.

N85-31152*# Draper (Charles Stark) Lab., Inc., Cambridge, Mass.
A DUAL SPIN SPACE STATION DESIGN
M. A. PALUSZEK *In* JPL Proc. of the Workshop on Identification and Control of Flexible Space Struct., Vol. 1 p51-65 1 Apr. 1985 refs
(Contract NAS9-16023)
Avail: NTIS HC A20/MF A01 CSCL 22B

A dual spin space station design is described. The space station has a cylindrical solar array that is spun to provide both gyroscopic stiffness to the space station and to stiffen the array structure. The platform is spun at the orbital angular rate. The space station is designed to have gravity gradient and aerodynamic restoring torques. An active control system is used to stabilize the station and store excess angular momentum until it can be removed from the station by magnetic torques. E.A.K.

N85-31215# Office of Technology Assessment, Washington, D.C.
CIVILIAN SPACE STATIONS AND THE US FUTURE IN SPACE Summary Report
1985 34 p
(OTA-STI-242) Avail: NTIS HC A03/MF A01

The OTA assessment of Civilian Space Stations and the U.S. Future in Space was studied. The study covered the essential technical issues surrounding the selection and acquisition of infrastructure in space, and enables Congress to look beyond these matters to the large context. A set of possible space goals and objectives that demonstrate the diverse opportunities open to us at this time was proposed. E.A.K.

N85-33173*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
TESTIMONY OF ROBERT A. FROSCH BEFORE THE SUBCOMMITTEE ON HUD AND INDEPENDENT AGENCIES OF THE SENATE COMMITTEE ON APPROPRIATIONS
R. A. FROSCH 14 Mar. 1985 4 p
(NASA-TM-87496; NAS 1.15:87496) Avail: NTIS HC A02/MF A01 CSCL 22B

An agreement between NASA and the Congress was arranged as part of the activities supporting the establishment of NASA Policy on Automation and Robotics for the space station. This agreement is dicussed. A panel brought together experts from industry, universities, national laboratories, other government agencies, and NASA to perform an independent study of how NASA could use automation and robotics in the space station in ways that would be most useful to carrying out the mission of the station, and that would lead to useful benefits to the U.S. economy and industry on the ground. Author

N85-33514*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
HOOP/COLUMN ANTENNA DEPLOYMENT MECHANISM OVERVIEW
B. B. ALLEN (Harris Corp., Melbourne, Fla.) and D. H. BUTLER *In* NASA. Ames Research Center 19th Aerospace Mech. Symp. p 23-37 Aug. 1985
Avail: NTIS HC A17/MF A01 CSCL 20K

The hoop/column antenna program is directed toward the development of a cost effective, large area, self deploying reflector antenna system. Large surface area antenna systems are required in future space missions involving improved land communications, Earth resources observation, and the study of intergalactic energy sources. The hoop/column antenna is a concept where a large antenna system can be packaged within the Space Transportation System (Shuttle) payload bay, launched into Earth orbit where it is released either for deployment as an Earth observation or communications antenna, or boosted into deep space as an intergalactic energy probe. Various mechanisms and support structures are described that are required to deploy the hoop, which is used to support the antenna reflective surface, and the column that is used to position the antenna feeds and the reflector. It also describes a proof-of-concept model (15 meters in diameter) that is currently being ground tested to determine the adequacy of the deployment mechanisms. Author

N85-33669# Joint Publications Research Service, Arlington, Va.
PSYCHOPHYSIOLOGICAL DISTINCTIONS OF ORGANIZATION AND REGULATION OF DAILY CYCLOGRAMS OF CREW ACTIVITIES DURING LONG-TERM SPACECRAFT
A. N. LITSOV and V. F. SHEVCHENKO *In its* USSR Rept.: Space Biol. and Aerospace Med., Vol. 19, No. 2, Mar. - Apr. 1985 (JPRS-USB-85-004) p 12-18 12 Aug. 1985 refs Transl. into ENGLISH from Kosmich. Biol. i Aviakosmich. Med. (Moscow), v. 19, no. 2, Mar. - Apr. 1985 p 12-16
Avail: NTIS HC A07

The results of analysis of work-rest cycles of the Salyut-6 and Salyut-7 prime crewmembers are discussed. The distribution of work-rest cycles within the day, week, month and the flight as a whole, their relation with other components of the time schedule, the effect of various factors involved on the health status and work capacity were studied. It was shown that specific work-rest cycles should be rigorously adhered to. It was demonstrated that proper planning and realization of work-rest cycles, as well as their correction during actual flight with respect to psychophysiological and biorhythmological variations are required to maintain good health condition and high work capacity of crewmembers. R.J.F.

N85-34153*# National Academy of Sciences - National Research Council, Washington, D. C. Commission on Engineering and Technical Systems.

SPACE STATION ENGINEERING AND TECHNOLOGY DEVELOPMENT: PROCEEDINGS OF THE PANEL ON IN-SPACE ENGINEERING RESEARCH AND TECHNOLOGY DEVELOPMENT

May 1985 194 p Proc. held in Hampton, Va., 21-22 May 1985 (Contract NASW-4003)
(NASA-CR-176110; NAS 1.26:176110) Avail: NTIS HC A09/MF A01 CSCL 22B

In 1984 the ad hoc committee on Space Station Engineering and Technology Development of the Aeronautics and Space Engineering Board (ASEB) conducted a review of the National Aeronautics and Space Administration's (NASA's) space station program planning. The review addressed the initial operating configuration (IOC) of the station. The ASEB has reconstituted the ad hoc committee which then established panels to address each specific related subject. The participants of the panels come from the committee, industry, and universities. The proceedings of the Panel on In Space Engineering Research and Technology Development are presented in this report. Activities, and plans for identifying and developing R&T programs to be conducted by the space station and related in space support needs including module requirements are addressed. Consideration is given to use of the station for R&T for other government agencies, universities, and industry. B.W.

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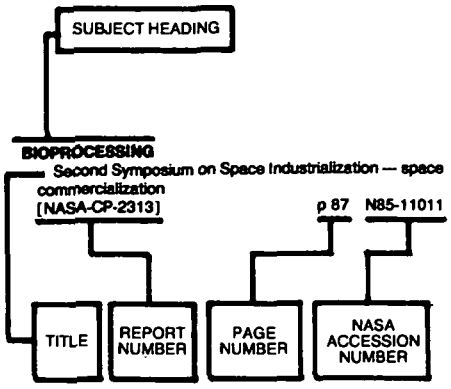

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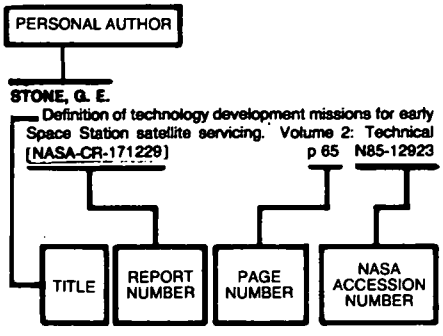

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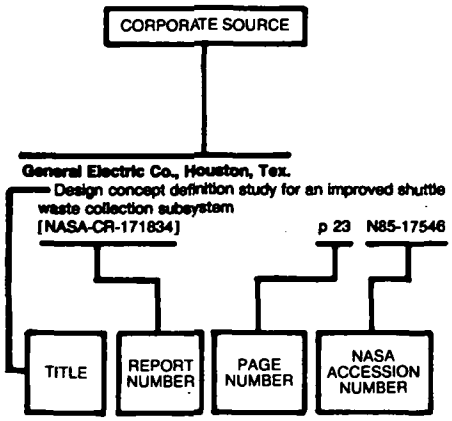

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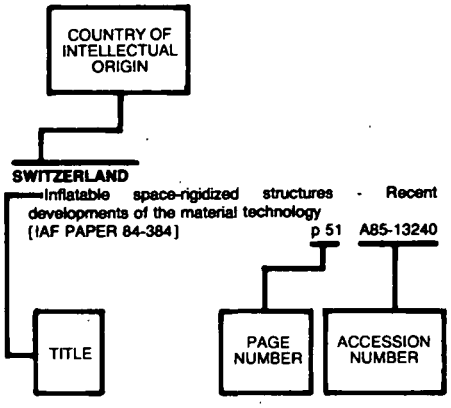

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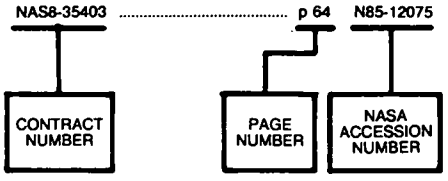

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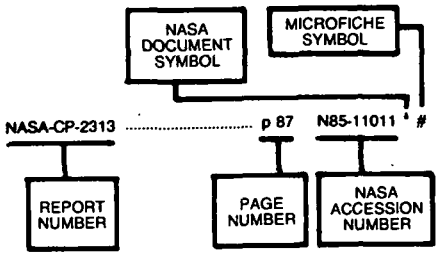

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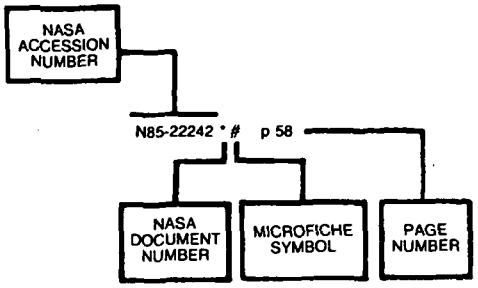

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